WATTECO

bob
ASSISTANT

USER MANUAL

HELLO,
I AM
BOB ASSISTANT !

Your personal assistant
for maintenance

Brand name: BoB Assistant US915MHz
Model name: 50-80-003
FCC ID: 2AGTV-50-80-003
IC: 32028-5080003

Contact: support@watteco.fr

Table of contents

I. Introduction

1.1. Overview

BoB Assistant is a low power LoRaWAN^{TM} compatible vibration and condition monitoring sensor for indoor and outdoor predictive maintenance industrial applications, coupled with a temperature sensor for environmental conditions, a push button and an RGB Led for User Interface.

BoB ASSISTANT will **measure and analyze** vibrations to detect abnormal behaviors of your industrial machines, with artificial intelligence capable of detecting operating anomalies before a failure occurs.

BoB ASSISTANT's casing is IP68 (dust and water proof). Edge AI makes it possible to process locally any vibration that comes from your machine. The amount of data transmitted is then optimized and secured, guaranteeing BoB ASSISTANT's autonomy for several years!

Very easy to install, **BoB ASSISTANT does not require any configuration**. Simply put BoB ASSISTANT on your machine, start it, and after a just few hours of learning, BoB ASSISTANT takes care of your machine!

1.2. Recommended fastening solutions

1.2.1. Magnets – default configuration

BoB ASSISTANT is delivered with a magnet kit, so you can put your device on your machine out of the box.
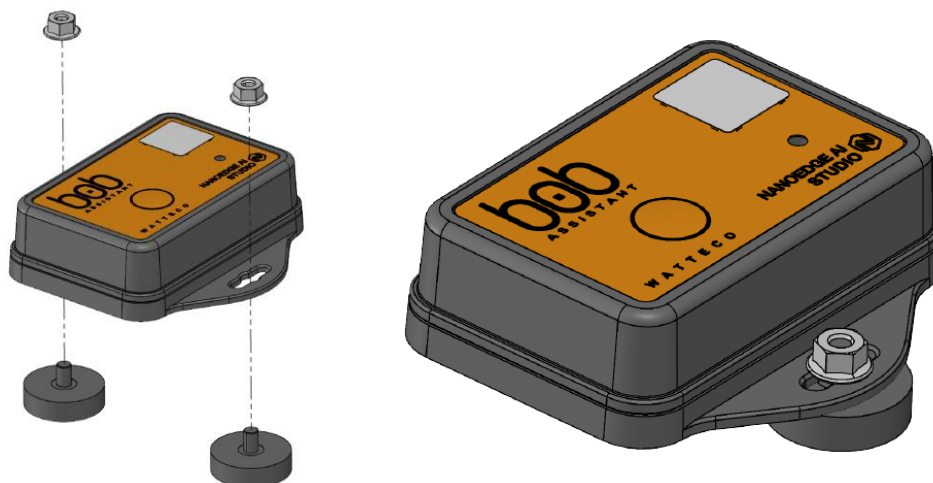
Default configuration:
- Magnet (x2):
  - o Manufacturer: BRUGGER MAGNET
  - o Reference: A22AG-KsM4x6
- Nut (x2):
  - o Manufacturer: BOSSARD
  - o Reference: BN11207 / 3061765

Validated references:
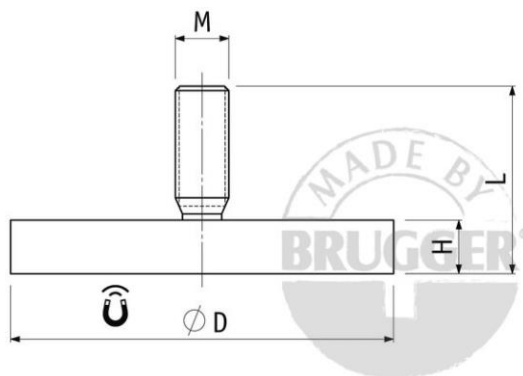
Manufacturer	Reference	Pull Force (kg)	Size (DxHxL / M)	Comments
BRUGGER	A43AG-KsM4x6	10	43x6x12mm / M4x6	Rubber coated magnet (outdoor use, max 60°C)
BRUGGER	A22AG-KsM4x6	6	22x6x12.5mm / M4x6.5	Rubber coated magnet (outdoor use, max 60°C)
ECLIPSE	E1053/NEO	14	20x6x15.5mm/ M4x9.5	Neodymium magnet (indoor use, max 80°C)
ECLIPSE	E1054/NEO	20	25x7x16.5mm / M5x9.5	Neodymium magnet (indoor use max 80°C)

These magnets references have been successfully tested as compliant with ETSI 300-019 class 5.2 when mounted on BoB ASSISTANT.

Class 5.2: all types of road vehicles used in areas with a well-developed road system, except tracked vehicles, motorcycles, scooters and other vehicles with low mass. The equipment can be mounted on surfaces which may be subjected to flying stones. The equipment may be mounted on passenger car

instrument panels to which high frequency vibrations from the engine, or from other parts connected to the engine, may be transmitted. This class also applies to fork lift trucks and trains with soft suspension and shock reducing buffers

1.2.2. Rivet
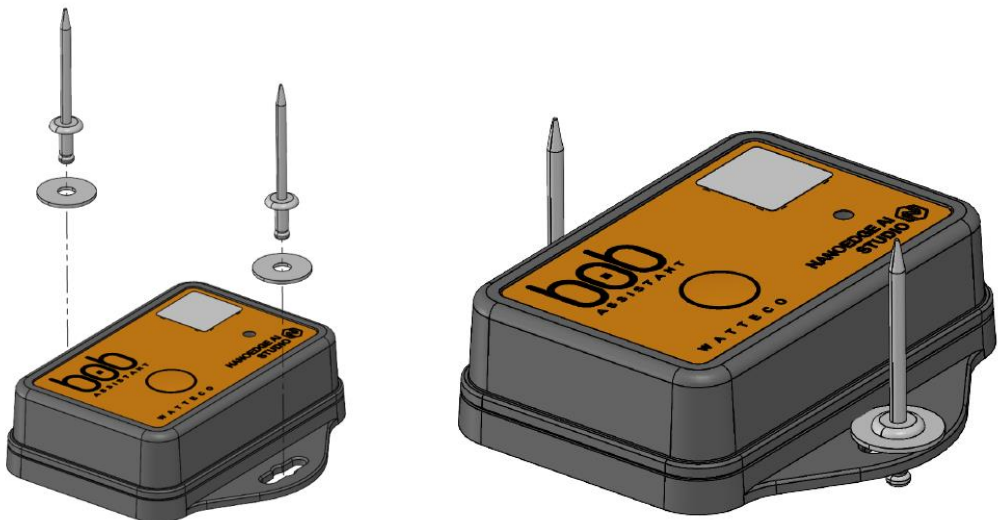
Rivet properties: Ø4mm, length 7/10.2/13.3mm
Drilling: Ø4.1mm / Ø4.2mm

Manufacturer	Reference	Comments
BOSSARD	BN 84545 / 8031215	Ring washer
BOSSARD	BN 1409 / 3206579	Rivet

1.2.3. Screw
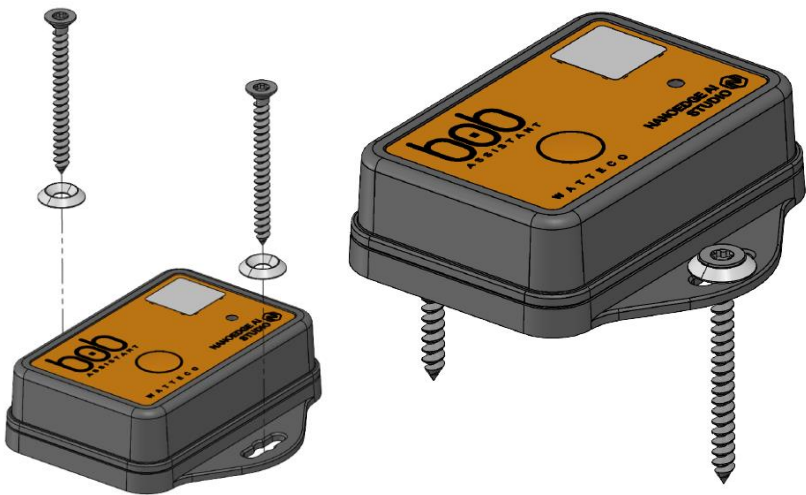
Manufacturer	Reference	Comments
BENE INOX	211309	TF TORX 4x45mm wood screw
WURTH	0455000304	Cup washer

1.3. Key Features

Radio:
Maximum transmission power 1W in the band 902.3 to 914.9MHz
LoRa SF7-SF9
LoRa 1.0 Class A
LoRa Sensitivity: -137 dBm

Temperature range:
Storage: -25°C to +55°C
Use: -20°C to +55°C

RGB LED:
Network availability,
Learning stage,
Vibration status,
Learning restored,
Learning erased,
Battery reset

Sensor:
3-Axis Accelerometer
Temperature measurement
Vibrations measurement 0Hz-12800 Hz
Adjustable periodic sampling

Firmware:
Automatic learning process and reporting by embedded artificial intelligence.
Possibility to add new learning or to reset learning.
AES-128 Encrypted data

Power supply:
Battery, 3,5 years (normal use)

Case:
Polyamide case
Dimensions: 76 x 79 x 23 mm
Weight: 75 grams
IP68 Protection

Tests and Certifications:
FCC marking, in accordance with FCC part 15 (15.201, 15.207, 15.209, 15.247)
Canada ICES-003

1.4. Conformity

1.4.1. FCC

1.4.1.1. FCC Compliance statement

This device complies with Part 15 of the FCC Rules.
Operation is subject to the following two conditions:
    (1) this device may not cause harmful interference.
    (2) this device must accept any interference received, including interference that may cause undesired operation.

This device has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:
—Reorient or relocate the receiving antenna.
—Increase the separation between the equipment and receiver.
—Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
—Consult the dealer or an experienced radio/TV technician for help.

This device complies with the FCC RF exposure limits and has been evaluated in compliance with mobile exposure conditions.
The equipment must be installed and operated with minimum distance of 20 cm of the human body.

    ⚠ **Caution: Changes or modifications not expressly approved by the party responsible for FCC compliance could void the user authority to operate the device. (Cf. FCC Part 15.21).**
    ⚠ Some conditions must be respected to maintain the FCC and IC compliance of the devices in USA and Canada. Please contact your reseller to have details

1.4.1.2. Supplier's declaration of conformity

Supplier's Declaration of Conformity
47 CFR § 2.1077 Compliance Information

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.
We,

Watteco
Pôle de Technellys
Bâtiment H
Boite aux lettres N°60
165 rue de la Montagne du Salut
56 600 LANESTER
FRANCE
www.watteco.com

hereby declare that the equipment bearing the model name specified below was tested conforming to the applicable FCC Rules and Regulations Title 47 Part 15 under the most accurate measurement standards possible, and that all the necessary steps have been taken and are in force to assure that production units of the same equipment will continue to comply with the Commissions requirements.

Unique Identifier:

Type of product: LoRaWAN vibration sensor
Brand name: BoB Assistant US915MHz
Model name: 50-80-003
FCC ID: 2AGTV-50-80-003
IC: 32028-50-80-003

1.4.2. ISED

1.4.2.1. ISED Compliance statement

ISED compliance statement

This device complies with Industry Canada license-exempt RSS standard(s).

Operation is subject to the following two conditions:

    (1) this device may not cause interference.

    (2) this device must accept any interference, including interference that may cause undesired operation of the device.

This device complies with ISED RF exposure limits and has been evaluated in compliance with mobile exposure conditions.

The equipment must be installed and operated with minimum distance of 20 cm of the human body.

This Class B digital apparatus complies with Canadian ICES-003

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence.

L'exploitation est autorisée aux deux conditions suivantes :

    (1) L'appareil ne doit pas produire de brouillage

    (2) L'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Cet appareil est conforme aux limites d'exposition RF d'ISDE et a été évalué conformément aux conditions d'exposition mobile. L'équipement doit être installé et utilisé à une distance minimale de 20 cm du corps humain.

Cet appareil numérique de classe B est conforme à la norme canadienne NMB-003.

    ⚠ Some conditions must be respected to maintain the FCC and IC compliance of the devices in USA and Canada. Please contact your reseller to have details

II. Functional overview

2.1. Life cycle and Operating modes

2.1.1. Functional preview

The following figure presents the different modes of operation of the device:

Startup & initialization
~a few minutes

- Check for LoRaWAN™ Network availability
- Check if there is Knowledge data in flash
- Check for vibration level
- Send "Device ON" state message at the end of the mode

Learning and reporting
~7 days

Will be skipped if existing knowledge data is in flash at startup

- Learn any new vibration signature
- Warn about learning session(s) progress
- Send periodic report on machine health (drift percentage, operating time, anomaly prediction)
- Send machine state (On/Off)
- Receive potential Downlink commands

Monitoring

- Send Alarm messages whenever the drift threshold is crossed (25% drift by default)
- Send periodic report on machine health (drift percentage, operating time, anomaly prediction)
- Send machine state (On/Off)
- Receive potential Downlink commands

Power off / Battery Swap / EOL

- Get to poweroff mode
- Battery swap
- If End of life => device recycling

2.1.2. Startup & initialization

The first step when you install BoB ASSISTANT on a machine you want to monitor will be to start the device, and make sure that:
- o   the LoRaWAN™ Network is reachable
- o   the vibration level of the machine is high enough to start learning

See §*2.2.1 Device Startup* for more details.

When the Startup & initialization mode is over, BoB ASSISTANT will then have 2 operating modes :
- o   Learning and Reporting
- o   Monitoring and Alerting

2.1.3. Operating modes

2.1.3.1.   Learning and reporting

This mode will last for 7 days, and will allow BoB ASSISTANT to learn the machine cycle(s). BoB ASSISTANT will start by a first learning session, and will then start reporting machine activity. Each time a new vibration signature is detected, BoB will start another learning session, in parrallel with the reporting mode.

7 days
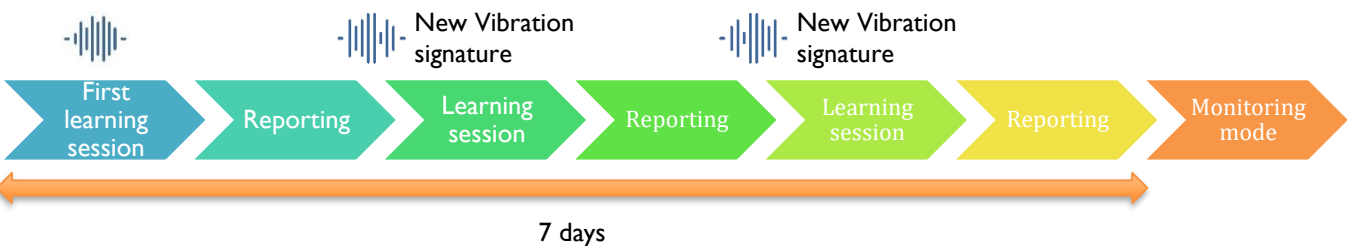
2.1.3.1.1. First learning session

Once BoB ASSISTANT is started, it will enter a first Learning session, which will last for a few hours (~1 to 4 hours for a machine with a simple vibration cycle, e.g. Air Conditionning unit).

This learning session will create a first dataset for the embedded AI algortihms and store the "screenshots" of the corresponding vibration signatures.

For each measure, it will perform a Fast Fourrier Transform (FFT):
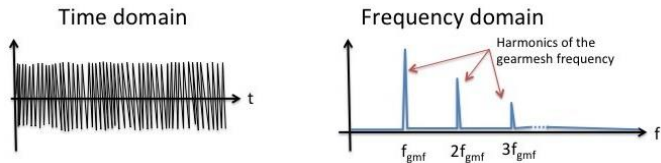
It will then add each new signal information to the vibration signature dataset.

For example, after a few hours of operation, the dataset could have more than 30 "screenshots" for the vibration signature of the machine:
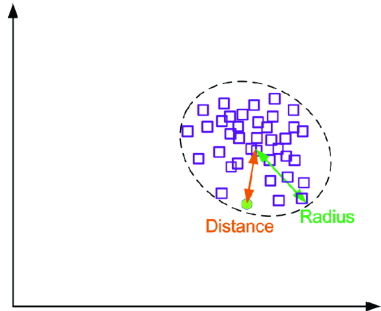
In the first seven days of operation, BoB ASSISTANT will continue monitoring new vibration signatures, and add them to the dataset.

After this period of time, no new vibration signature will be added to the dataset, unless it is required through a Downlink command (see §*IV Downlink (LoRa to device)*).

During a learning session, BoB ASSISTANT will wake up every 60 seconds (default value, configurable, see §*4.2 Change sampling period*) to sample the signal, perform the FFT of the vibration signature and compare and record the sampling to the dataset. BoB ASSISTANT's dataset is able to record up to 20 different vibration signature zones.
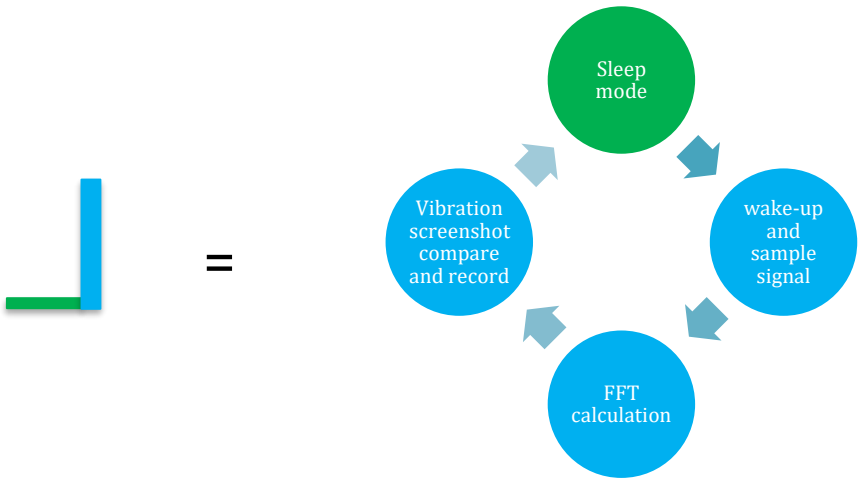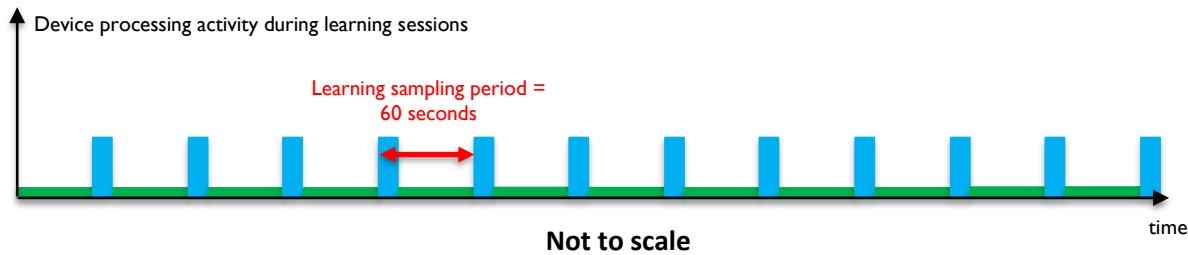
Please be advised:
- o **if the vibration level was high enough at startup, but then is going below the minimum level of detection in the first 7 days, the device might get stuck in a Learning session. In this case, we advise to change BoB location on the machine to put it as close as possible to the vibration source, or on a less vibration-insulated element.**
- o **If a new machine cycle appears after the first seven days (e.g. production rate increase), it might be considered by BoB ASSISTANT as an anomaly. In this case, you will have to send a Downlink command to BoB ASSISTANT in order to add this cycle to the dataset.**

During the Learning session, the device will send messages to keep you posted on the learning percentage (0 to 100%), for example:

Device communication activity during Learning sessions

```
   0        1        2        3        4        5
```

Not to scale   time
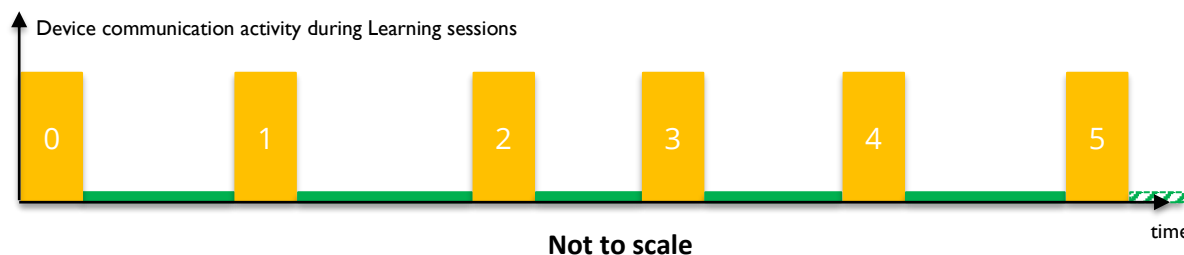
Each message will send details on the progress percentage of the learning session (most of the time 5 messages from 0 to 100, with a 20% step), environmental information (temperature, vibration level, peak frequency), and a screenshot of the FFT (see §*3.2.1 Payload structure*)

2.1.3.1.2. Reporting

After the first Learning session, BoB ASSISTANT will switch to the reporting mode, where it will analyze the machine vibration every 10 minutes:

Device activity during reporting

Report sampling period = 10 minutes

Not to scale   time
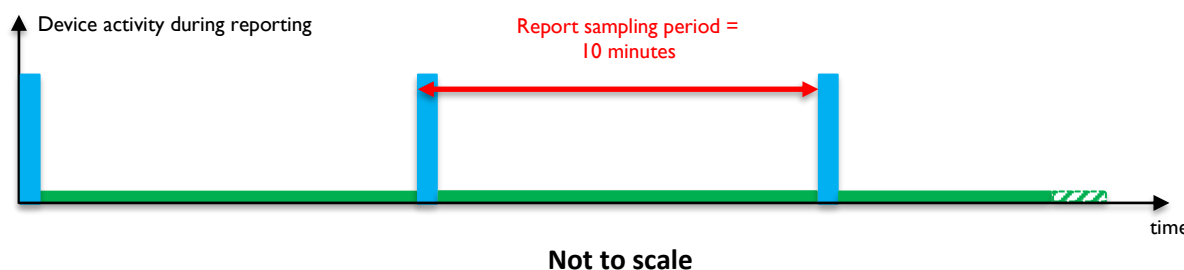
BoB ASSISTANT will process each sample to define whether a new learning session is needed, or to prepare a report of the activity sent in periodic reports (every 3 hours, not configurable) concerning the health of the machine during this period, regarding:
- the operation time of the machine,
- its vibration level,
- the vibration drift percentage,
- and prediction on potential failure distance in time, based on the vibration analysis of the last 24 hours, the last 30 days, and the last 6 months

See §*3.3.1 Payload structure* for more details on report messages content.

Device communication activity during reporting

Reporting period = 3 hours

Not to scale   time
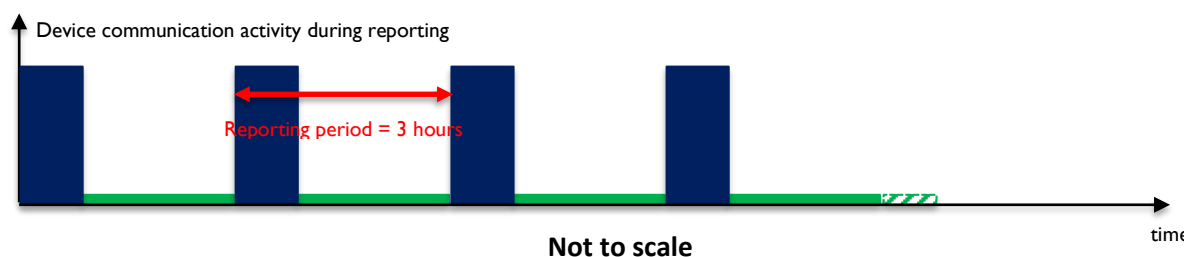
2.1.3.1.3. End of learning mode

At the end of the learning mode (7 days), BoB ASSISTANT will have completed its dataset.

For example, BoB ASSISTANT could have the following dataset, with two distinct vibration cycles with their respective standard deviation from average point (radius)
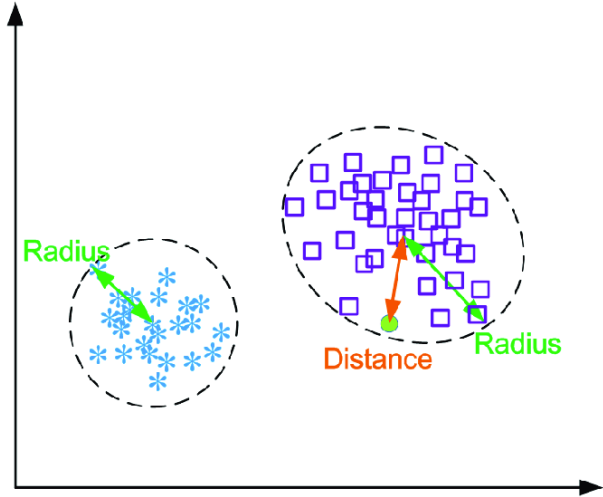
2.1.3.2. Monitoring

After the learning mode, BoB ASSISTANT will switch to Monitoring mode, where it will continue its reporting activity, and will start sending alarms if the drift in the vibration signature pass a defined threshold (default value is 25% drift).

For each signal sampling (every 10 minutes by default), BoB ASSISTANT will process the sampled signal, and compare it to its dataset:
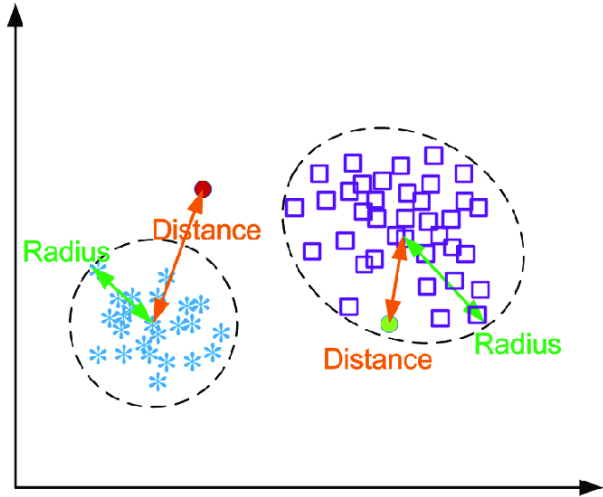
For the green sample, the distance/drift of the point compared with the average point is within the defined threshold (default drift percentage threshold is 25%). In this case, BoB will add the recorded data to prepare the periodic report

For the red sample, the distance/drift of the point compared with the average point is beyond the defined threshold. In this case, BoB will send an ALARM MESSAGE. The drift percentage triggering an ALARM MESSAGE can be customized, see §*4.4 Change ALARM MESSAGE threshold*.

The alarm message can then trigger an e-mail/SMS alert at the platform level (cloud or on premise), which will be sent to maintenance teams for machine inspection.

2.1.3.3. Configurable parameters

Some parameters of BoB ASSISTANT can be tuned to adapt to the equipment operation. For more information on how to change the parameters see §*IV Downlink (LoRa to device)*

2.1.3.3.1. Sampling period

BoB ASSISTANT will periodically wake up to sample the vibration signal of the machine (sampling duration = 0.25s). By default, it will wake up every 60 seconds during the learning and reporting mode (first 7 days), and will then wake up every 10 minutes during the monitoring mode.

Some machines could need to have some different settings, e.g. machines with short operating cycles.

Mode	Learning period	Monitoring Period
Very Fast	10 sec	20 sec
Fast	20 sec	2 min
Legacy	60 sec	5 min
Default	**60 sec**	**10 min**
Slow	2 min	10 min

Please be advised: setting BoB ASSISTANT in Fast or Very Fast mode will have consequences on the device lifespan.

2.1.3.3.2. State messages

BoB ASSISTANT will send machine status when it detects that the machine is turning ON or OFF, based on sample results. These messages are enabled by default, they can also be disabled.

State message parameters
Enable State Message (**default**)
Disable State Message

Please be advised: for machines with very short cycles, it is recommended to disable the state messages, as it could have dramatic effect on the device lifespan, see Downlink section : *§4.3 Enable/disable machine start/stop STATE MESSAGE*.

2.1.3.3.3. Battery reset

It is possible to reset the battery consumption counter after battery replacement on the device by sending a specific downlink to the device.

It is also possible to reset the battery consumption counter using the button, see *§2.3 Battery Replacement* for more details.

2.1.3.3.4. Vibration threshold management

In some cases, the environment of the equipment is prone to vibration parazites (e.g. 2 large motors close to each other). In that case, BoB could sense parasitic vibrations, which could corrupt the report data or even alarm data.

It is possible to change the vibration threshold to consider whether the machine is working or not and so prevent from getting irrelevant data.

See *§4.7 Change Vibration threshold for On/Off detection – New*

2.2.   Device Interaction

2.2.1. Device Startup

2.2.1.1.   Turning BoB ASSISTANT ON

BoB ASSISTANT is OFF by default when delivered.
In order to start BoB ASSISTANT, you need to:

- Place BoB ASSISTANT on the machine you want to monitor(see §*1.2 Recommended fastening solutions*), **and make sure that the machine is running**. It is best to install BoB on a new equipment, or a machine, which has just been reviewed by maintenance.
- Turn the device ON by pushing on the button for more than 3 seconds, the LED will then get to green 🟢 , followed by 2 green blinks 🟢🟢 if hardware test is ok.

When the Led first turns green, you can release the button, the device is ON

2.2.1.2.   Startup and trouble shooting

2.2.1.2.1.   Startup

Once switched ON, BoB ASSISTANT starts its initialization mode. It will first verify if there is knowledge data stored in flash memory, which needs to be restored. If there is knowledge data in flash, it will then display the restore sequence LED: 🟣🟣🟣🟣🟣.

It then tries to reach the LoRaWAN^{TM} Network using OTAA (Over The Air Activation) and ensures that the perceived vibration level is sufficient (>0.01g). During this mode, the LED is continuously blue (🔵).

The initialization mode lasts for around 90 seconds (depending on LoRaWAN^{TM} Network coverage)

A the end of this initialization mode, if the device has reached the LoRaWAN^{TM} Network, and the perceived vibration level of the machine is sufficient (>0,01g), then the device will blink 5 times in green 🟢🟢🟢🟢🟢, the LED will stay OFF and BoB ASSISTANT is ready to start its duty and enter the Learning mode (see §*2.1.3.1 Learning*)

BoB ASSISTANT will then send a state message to warn that the device has started and everyting is OK (see §*3.5 STATE MESSAGE*
payload structure)

The following figure displays the different steps of the startup, **if everything is OK**, **and there is no knowledge restored**:

→3s later

Turn BoB ASSISTANT ON
(green + 2 green LED blinks)

Startup and initialization
(Continuous Cyan LED)

→up to ~1minute and 35 seconds

End of initialization
(5 green LED blinks)

The following figure displays the different steps of the startup, **if everything is OK**, **and there is knowledge restored**:

→3s later

Turn BoB ASSISTANT ON
(green + 2 green LED
blinks)
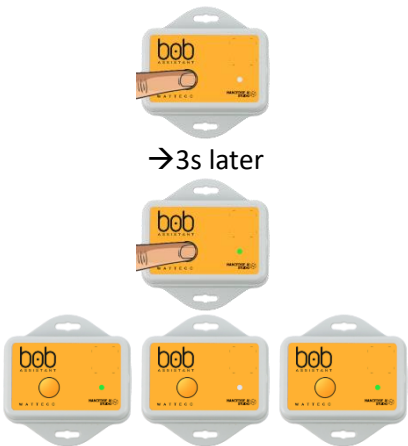
Knowledge presence to
restore (5 pink LED
blinks)

Startup and initialization
(Continuous Cyan LED)

→up to ~1minute and 35 seconds

End of initialization
(5 green LED blinks)

2.2.1.2.2. Startup flowchart

Poweroff

No → Button pushed for 2s ?

Display Init LED

Yes → Hardware self test OK? → No

Display Hardware test OK LED sequence

Yes

Knowledge in flash?

No

Yes → Restore knowledge data

Display knowledge restore LED sequence

Sleep for 24h

Start Join Network sequence ← Increment retry counter ← Increment join sequence counter

Display Startup LED Continuous Cyan

Network joined ?

No → Max retry (8) reached ?

No → Increment retry counter

Yes → Max join sequence(3) reached ? → No → Increment join sequence counter

Yes

Display LoRa error LED sequence

Yes → Knowledge Restored?

Yes

No → Sleep for 24h

Start Vibration testing sequence ← Increment vibration test retry counter + sleep for 5 minutes ← Increment vibration sequence counter

Yes

Vibration error LED sequence

Vibration OK ?

No → Max retry (3) reached ? → No

Yes → Max vibration sequence(3) reached ? → No → Increment vibration sequence counter

Yes

Startup LED sequence

2.2.1.2.3.   Troubleshooting

Please be advised: If the LoRaWAN^{TM} Network was unreachable or if the vibration level is below the minimum level, the device will not start its duty, but will go back to deep sleep mode. To restart the device, follow §*2.2.1.1 Turning BoB ASSISTANT ON*

The following table summarizes the different sequences displayed by the LED, depending on the origin of the problem:

Origin of the problem	Corresponding LED sequence on BoB ASSISTANT	Problem solving
LoRaWAN^{TM} Network unreachable	10x 🔴🟣	- Check device declaration on the LoRaWAN^{TM} Network Server (NS), make sure that DEV_EUI, APP_EUI and APP_Key are all correctly declared on the NS. If you did not receive the keys for your device, please contact us. - Check Network coverage on the BoB ASSISTANT installation location. If BoB ASSISTANT is out of range, you can either add a gateway if you run your own network, or contact your operator to check for solutions
Vibration level below the minimum level	10x 🔴🔵	Change BoB ASSISTANT location on the machine, and try to put it as close as possible to the vibration source, or on a less vibration-insulated element. BoB ASSISTANT perceives vibrations of very low amplitude (minimum 0.01g), there is surely a suitable place!
Hardware problem	10x 🔴🟠	In this case, BoB ASSISTANT must be replaced and we invite you to contact our support team

2.2.2. Device power off

In case you need to stop BoB ASSISTANT (e.g. maintenance operation), it is possible to turn BoB ASSISTANT off, without loosing the data set (knowledge) learnt during the first 7 days.

To do so, push the button for ~10s, after you get the green/orange/red sequence on the LED. Once the LED is red, you can release the button, the device will go off after sending a STATE message.

→Press the button for ~1s

→Press the button for ~4s

Turn BoB ASSISTANT OFF
(green->orange->red)

→Press the button for ~10s

Release the button when the LED is red
BoB ASSISTANT will then send the STATE message to warn that it gets Off (**can take up to 10 minutes**)
Once the STATE message is sent, the LED will show the following sequence:

To turn BoB Assistant back on, follow the steps described in §2.2.1.1 Turning BoB ASSISTANT ON

2.2.3. Knowledge data set erase

In case you want to reset BoB ASSISTANT knowledge, it is possible to use the button to do so.

Pushing the button for more than 20s, will display the "poweroff" green/orange/red sequence on the LED, followed by pink Led after 20s. Once the LED is pink, you can release the button, the device will erase the knowledge data stored in flash, and go off after sending a STATE message.

→Press the button for ~1s

→Press the button for ~4s

→Press the button for ~10s

Turn BoB ASSISTANT OFF
(green->orange->red)

→Press the button for more than 20s

Release the button when the LED is pink
The device will then display 5x ⬤ ⬤ sequence

BoB ASSISTANT will then send the STATE message to warn that it erased the knowledge data and gets Off (**can take up to 10 minutes**)

Once the STATE message is sent, the LED will show the following sequence:

2.2.4. Battery value reset

After changing the battery (see *§2.3 Battery Replacement*), it is possible to reset the battery level sent in the frames by the device.

There a 2 possible ways, either by downlink (see *§4.5 Reset battery value*) or by using the button, once the device has re-started (initialization phase is done, the device is connected to the network).

Repeat 5 times:

Reset battery value

→Press the button, wait 1s, then press the button again
After 5 consecutive button press, the device will then display 5x white Led blinks

BoB ASSISTANT will then send the STATE message to warn that it erased the knowledge data and gets Off (**can take up to 10 minutes**)

2.3. Battery Replacement

It is possible to change the battery once the device's battery has run out of energy.
WARNING: ESD might damage the integrity of the device, it is advised to use anti-static equipment when the battery is replaced.

To replace the battery, open the device using a **Torx 8** screwdriver by removing the 4 screws:

Remove the battery from the battery holder.

Replace the battery with the following reference:
- o **HCB ER14505M** (Primary Li-SOCl$_2$, Nominal capacity 2100mAh, Nominal Voltage 3.6V, maximum continuous discharge current 400mA)
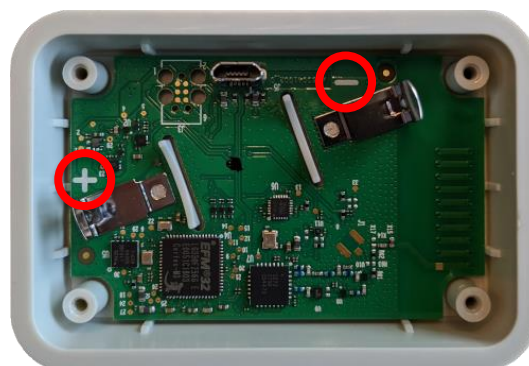
When replacing the battery, please make sure that the polarity is correct

Put the lower case back in place and screw the 4x Torx 8 screws back in place **with a 0.5Nm torque**.

Before screwing back the Torx screws, make sure that the seal, which guarantees the IP68 level, is correctly back in place:

Once the battery has been replaced, it is possible to reset the battery level to 100%.

Please check *§4.5 Reset battery value – New* to reset the battery level through Downlink command or *§2.2.4 Battery value reset* to manually reset the battery level using the button.

2.4. BoB ASSISTANT v2.0 frequency analysis

Monitored frequencies = 0-400Hz (LF) & 0-12800Hz (HF) for:
- **Learning messages**
- **Report messages**
- **Alarm messages**

FFT Report = 32 values 0-3200Hz (step=100Hz) for:
- **Learning messages (bytes [8-39])**
- **Alarm messages (bytes [8-39])**

Peak Frequency value = 0-12800Hz (3,125Hz step 0-350Hz and 100Hz step 350Hz-12800Hz)
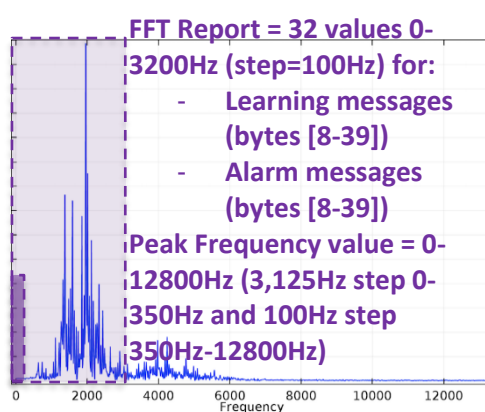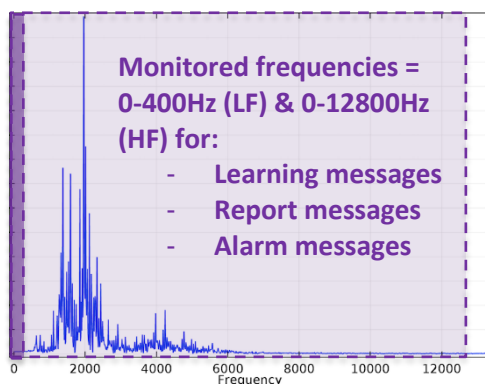
FFT calculation is done on the 0-12800Hz window (on 128 steps of 100Hz each), but FFT report only includes the 0-3200Hz window values

2.5. Frame identification header

Each type of message is identified using the byte 0 of the payload, considered as a header to decode the rest of the frame.

Example: for the 'report message' frame, the payload is identified by the byte 0 = 0x72 (decimal = 114). See §*III Uplink payloads (Device to LoRaWAN server)* for more details.

2.6. Peak frequency value

The **peak frequency** value is calculated using the following values.

- o BoB Assistant V2 will make 2 consecutive samplings, with 2 distinct sampling rates
  - o FREQ_SAMPLING_ACC_LF = 800Hz
  - o FREQ_SAMPLING_ACC_HF = 25600Hz

The FREQ_SAMPLING_ACC_LF sampling is done to observe potential drift in low frequencies with a relatively high precision, whereas the FREQ_SAMPLING_ACC_HF allows the sampling of a large frequency window, with less precision.

The **peak frequency** and associated **peak value** are reported using either the FREQ_SAMPLING_ACC_LF sampling information (for frequency values from 0 to ~350Hz, with a 3,125Hz step), or the FREQ_SAMPLING_ACC_HF (for frequency values from ~350Hz to 12800Hz, with a 100Hz step)

Note: Due to frame size limitation implied by the LoRaWAN^{TM} protocol, a compromise has been made for the FFT values sent: 32 values are sent between 0 and 3200Hz, with a 100Hz step. Sending the full frequency window in the FFT values (0 to 12800Hz) would make the step too wide (400Hz) and not relevant.

2.7.   Manufacturing configuration

2.7.1. Device default configuration

When delivered, the device will be **OFF**. To switch the device **ON**, please see *§2.2.1.1 Turning BoB ASSISTANT ON*.

The LoRaWAN^TM configuration is OTAA (Over The Air Activation, with DevEUI, and AppEUI/JoinEUI contained in the QR code of the product sticker, see QR code). AppKey is transmitted along with DevEUI and AppEUI/JoinEUI through a secured platform.

2.7.2. Labels

Both front and rear labels are compliant with TR005 LoRaWAN® Device Identification QR Codes from the LoRa Alliance®.

2.7.2.1.   Front Label

Label	Label content
70B 3D 531C0002F23	QRCode content : LW:D0:AAAAAAAAAAAAAAAA:DDDDDDDDDDDDDDDD:01280029:P5080003001:Ssssssssss:Ccccc AAAAAAAAAAAAAAAA AppEUI/JoinEUI (example:70B3D531C1120021) DDDDDDDDDDDDDDDD DevEUI (example: 70B3D531C0002904) 0128 LoRa VendorID 0029 VendorProfileID / LoRa Index (hex format 0x29 = 41) 5080003001 Watteco Family Code (example 5080003001=50-80-003-001) ssssssssss Hex format Serial Number* cccc CRC-16 (Modbus) of the QRCode content** QRCode content example: LW:D0:70B3D531C1120021:70B3D531C0002904:01280029:P5080003001:S002EA5AE55:C34A7 Cleartext content: "70B3D531C0002F23" = Device DevEUI

*To retrieve the Serial Number ssssssssss :
-    Transform the hex value of the field ssssssssss = 002EA5AE55 to decimal value
     o   0x002EA5AE55 (hex)= 0782610005 (decimal)
-    Retrieve the batch number and serial number of the device in the batch:
     o   078261 are the last 6 numbers of Watteco's batch number 078261 <=> 0**078261** batch number
     o   0005 is the serial number in the batch

**CRC-16/Modbus example :
For the following content:
LW:D0:70B3D531C1120021:70B3D531C0002904:01280029:P5080003001:S002EA5AE55
⇨   CRC-16 modbus calculation gives cccc = 34A7

2.7.2.2. Rear Label

Label	Label content
FCC ID: 2AGTV-50-80-003 IC: 32028-5080003 **Watteco** BoB Assistant US 915MHz 50-80-003-001 WW/YY DDDDDDDDDDDDDDDD	QRCode content : LW:D0:AAAAAAAAAAAAAAAA:DDDDDDDDDDDDDDDD:01280029:P5080003001:Ssssssssss:Ccccc AAAAAAAAAAAAAAAA AppEUI/JoinEUI (example: 70B3D531C1120021) DDDDDDDDDDDDDDDD DevEUI (example: 70B3D531C0002904) 0128 LoRa VendorID 0029 VendorProfileID / LoRa Index (hex format 0x29 = 41) 5080003001 Watteco Family Code (example 5080003001=50-80-003-001) ssssssssss Hex format Serial Number* cccc CRC-16 (Modbus) of the QRCode content** QRCode content example: LW:D0:70B3D531C1120021:70B3D531C0002904:01280029:P5080003001:S002EA5AE55:C34A7 Cleartext content: "Watteco" = Device vendor "BOB Assistant US 915MHz" = Device description "50-80-003-001" = Device family code/reference "51/22" = WW/YY of production (here: W51 of Y2022) "70B3D531C0002F23" = Device DevEUI

*To retrieve the Serial Number ssssssssss :
- Transform the hex value of the field ssssssssss = 002EA5AE55 to decimal value
  - 0x002EA5AE55 (hex)= 0782610005 (decimal)
- Retrieve the batch number and serial number of the device in the batch:
  - 078261 are the last 6 numbers of Watteco's batch number 078261 <=> 0**078261** batch number
  - 0005 is the serial number in the batch

**CRC-16/Modbus example :
For the following content:
LW:D0:70B3D531C1120021:70B3D531C0002904:01280029:P5080003001:S002EA5AE55
⇨ CRC-16 modbus calculation gives cccc = 34A7

III. Uplink payloads (Device to LoRaWAN server)

3.1. Introduction

BoB ASSISTANT sends 4 types of messages: **LEARNING**, **REPORT**, **ALARM** and **STATE**. The payload for each message has a different structure and each message type is identified with byte 0 (header).

- **LEARNING** occurs only during the Learning mode (during the first 7 days);
- **REPORT** is sent each 3 hours (default configuration);
- **ALARM** message is sent when anomaly level reaches XX% (25% default).
- **STATE** is sent when the measured equipment changes its state from ON to OFF or OFF to ON (start/stop), when vibration test at startup fails, or when the device is turned on or off (with or without flash erase).

STATE message is the first applicative payload sent by the device after power-on.

A javascript codec (ES5 and ES6) is provided to decode the frames sent by the device. It is available at the following URL : https://github.com/Watteco/Codec-BoBAssistant-Javascript

3.2. LEARNING MESSAGE

3.2.1. Payload structure

Evolutions compared to previous version of the device are in red in the following table

Byte	Definition / *codec attribute*	Value (dec)	Real_Value (dec)	Unit	Range	Type	Comments
0	Header / *learning*	108		const		N/A	hex=0x6C => **l**earning header
1	Learning percentage / *learningpercentage*	0~100	Value	%	[0,100]	integer	0-100: Percentage of the learning process
2	Vibration level (vl_1) / *vibrationlevel*	0~127	Value				Vibration level measured **for the last sample of the current learning stage**
3	Vibration level (vl_2) / *vibrationlevel*	0~127	Value	g	[0,127]	float	vl=(vl_1*128+vl_2+vl_3/100)/10/121.45; The codec will calculate the maximum vibration level value and return it in the "*vibrationlevel*" attribute
4	Vibration level (vl_3) / *vibrationlevel*	0~127	Value				The threshold of vibration level is 0.01g
5	Peak frequency index / *peakfrequencyindex*	0~256	Value+1		[0,256]	integer float	Frequency index value with the highest vibration level measured **for the last sample of the current learning stage** Frequency_index=Value+1; The codec will calculate the Frequency index value and return it in the "*peakfrequencyindex*" attribute If *peakfrequencyindex* value is <128 then Peak frequency step =3,125Hz and the corresponding peak frequency value is Frequency_value=(Value+1)*FREQ_SAMPLING_ACC_LF/256 If *peakfrequencyindex* value is >= 128 then Peak frequency step =100Hz and the corresponding peak frequency value is Frequency_value=((Value & 0x7F)+1)*FREQ_SAMPLING_ACC_HF/256 The Frequency value is not calculated by the codec and must be calculated by your web application.
6	Temperature / *temperature*	0~127	Value-30	°C	[-30,97]	integer	Temperature measured during **the last sample of the current learning stage** The Value is constrained to be with a range [-30,97] The codec will calculate the temperature value and return it in the "*temperature*" attribute
7	Learning type / *learningfromscratch*	0~1	Value			boolean	Learning from scratch or additional learning: 1: Learning from scratch; 0: Additional learning
8~39	FFT signal / *fft* [0;31]	0~127		g; Hz		float float float	FFT signal measured **for the last sample of the current learning stage** **Value_g**=Value*vl/127; (see bytes 2-3-4 for vl value calculation) The codec will calculate the g value and return it in the "*fft*" attribute **Frequency_hz**=(i+1)*FREQ_SAMPLING_ACC_HF/256 (i is the index of FFT array, begins from 0, ends by 31, frequency step =100Hz) The Frequency value is not calculated by the codec and must be calculated by your web application.

See § 2.6 P for details on FREQ_SAMPLING_ACC_LF and FREQ_SAMPLING_ACC_HF

3.2.2. Learning message payload data extraction example

Learning payload:
0x6c00001f3f013601407f5b4467393c303176301c332b61345b7e303e2318373f333f2231444a4245

byte	0	1	2	3	4	5	6	7
	6c	00	00	1f	3f	01	36	01

byte	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	31
	40	7f	5b	44	67	39	3c	30	31	76	30	1c	33	2b	61	34	5b	7e	30	3e	23	18	37	3f	33	3f	22	31	44	4a	42	45

Byte	Definition	hex	dec	Value	Unit	Comments
0	Header	6c	108	108=ASCII "l" =>Learning frame	-	Learning header
1	Learning percentage	00	0	0%	%	Learning percentage = 0% ➔ the device just started a learning session
2	Maximum Vibration amplitude (3 bytes) Vibration level 1 (vl_1)	00	0	$vl=(vl\_1*128+vl\_2+vl\_3/100)/10/121.45$ => $vl=(0*128+31+68/100)/10/121.45$ $vl=0.026$	g	vl=0.026g
3	Vibration level 2 (vl_2)	1f	31			
4	Vibration level 3 (vl_3)	3f	63			
5	Peak frequency index (frequency with the highest vibration level recorded)	01	1	Freq_index=Value+1=2 Freq_value=(Value+1)*FREQ_SAMPLING_ACC_LF/256=2*800/256=6,25	- Hz	Freq_index=2 (<128) Freq_value=6,25Hz (reminder: FREQ_SAMPLING_ACC_LF=800)
5	Temperature	36	54	54-30=24	°C	Hardware offset
6	Learning type	01	1	1: Learning from scratch	boolean	The device is learning from scratch
18-26	FFT values [0;31]	40;7f;5b; 44;67;39; 3c;30;31; 76;30;1c; 33;2b;61; 34;5b;7e; 30;3e;23; 18;37;3f; 33;3f;22; 31;44;4a; 42;45	64;127;91; 68;103; 57; 60;48;49; 118;48;28; 51;43;97; 52;91;126; 48;62;35; 24;55;63; 51;63;34; 49;68;74; 66;69	FFT[0] = 64*vl/127 = 64*0.026/127 = 0.013g FFT[0] is for frequency index 0 => Frequency_hz=(i+1)*FREQ_SAMPLING_ACC_HF/256 = (0+1)*25600/256 = 100Hz	g	

3.2.3. FFT signal details

The vibration data sent in the bytes 8 to 39 of the Learning message is a simplified version of what is actually seen by the sensor (due to the LoRaWAN bandwidth limitation).

The sensor will send a 32 entry table FFT[0;31], with each entry of the table corresponding with the acceleration value of each frequency step.

For example, using the previous payload data:

| 18-26 | FFT values [0;31] | 40;7f;5b; 44;67;39; 3c;30;31; 76;30;1c; 33;2b;61; 34;5b;7e; 30;3e;23; 18;37;3f; 33;3f;22; 31;44;4a; 42;45 | 64;127;91; 68;103; 57; 60;48;49; 118;48;28; 51;43;97; 52;91;126; 48;62;35; 24;55;63; 51;63;34; 49;68;74; 66;69 | FFT[0] = 64*vl/127 = 64*0.026/127 = 0.013g

FFT[0] is for frequency index 0 => Frequency_hz=(i+1)*FREQ_SAMPLING_ACC_HF/256 = (0+1)*25600/256 = 100Hz | g | |

The corresponding decoded data would be:

Frequency bin	FFT[0,31] value	Frequency	Vibration level
0	64	0-100Hz	0,0131
1	127	100-200Hz	0,0260
2	91	200-300Hz	0,0186
3	68	300-400Hz	0,0139
4	103	400-500Hz	0,0211
5	57	500-600Hz	0,0117
6	60	600-700Hz	0,0123
7	48	700-800Hz	0,0098
8	49	800-900Hz	0,0100
9	118	900-1000Hz	0,0242
10	48	1000-1100Hz	0,0098
11	28	1100-1200Hz	0,0057
12	51	1200-1300Hz	0,0104
13	43	1300-1400Hz	0,0088
14	97	1400-1500Hz	0,0199
15	52	1500-1600Hz	0,0106
16	91	1600-1700Hz	0,0186
17	126	1700-1800Hz	0,0258
18	48	1800-1900Hz	0,0098
19	62	1900-2000Hz	0,0127
20	35	2000-2100Hz	0,0072
21	24	2100-2200Hz	0,0049
22	55	2200-2300Hz	0,0113
23	63	2300-2400Hz	0,0129
24	51	2400-2500Hz	0,0104
25	63	2500-2600Hz	0,0129
26	34	2600-2700Hz	0,0070
27	49	2700-2800Hz	0,0100
28	68	2800-2900Hz	0,0139
29	74	2900-3000Hz	0,0151
30	66	3000-3100Hz	0,0135
31	69	3100-3200Hz	0,0141

The corresponding visualization of the data would be:
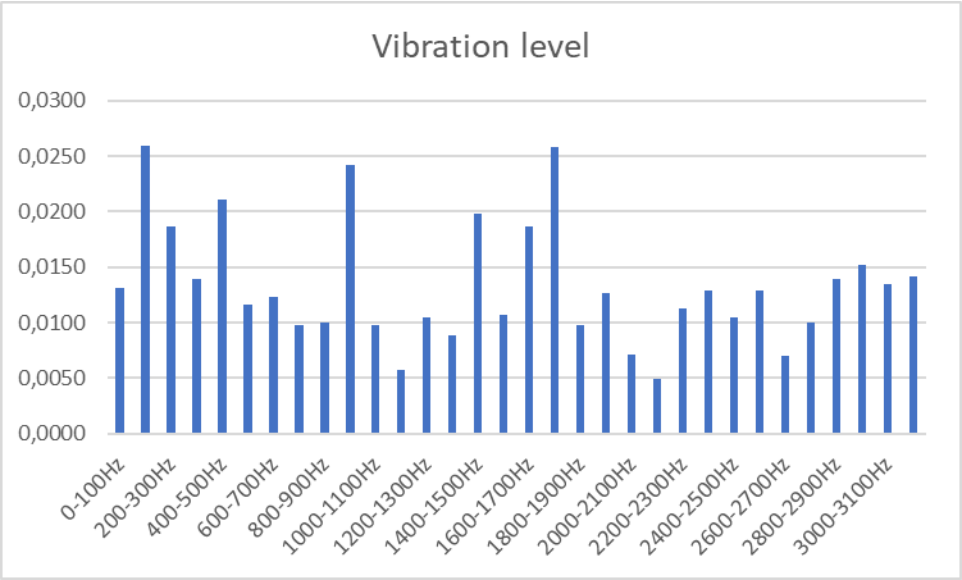
3.3.   REPORT MESSAGE

3.3.1. Payload structure

Evolutions compared to previous version of the device are in red in the following table

Byte	Definition / *codec attribute*	Value (dec)	Real_Value (dec)	Unit	Range	Type	Comments
0	Header / *report*	114		const		N/A	hex=0x72 => **r**eport header
1	Anomaly level (in %) / *anomalylevel*	0~127	Value*100/127	%	[0,100]	integer	Vibration drift percentage between the measured vibration signature and the vibration signature learned by BoB ASSISTANT
2	Operating time / *vibrationpercentage*	0~127	Value*report_period/127	Minute	[0, report_period]	integer	Operating time of the monitored equipment over the report period (report period=byte 6) The codec will return in the attribute "*vibrationpercentage*" the percentage of operating time over the last period
3	[0%-10%] anomaly level time / *goodvibration*	0~127	Value*operating time/127	Minute	[0, report_period]	integer	Time, in minutes, spent in the [0%-10%] anomaly level range over the report period The codec will return in the attribute "*goodvibration*" the percentage of time spent in the [0;10%] vibration drift range over the last period
4	Alarm Number / *nbalarmreport*	0~127	Value		[0,127]	integer	Number of alarms during this report period
5	Temperature / *temperature*	0~127	Value-30	°C	[-30,97]	integer	The codec will calculate the temperature value and return it in the "*temperature*" attribute
6	Report period (R_V) / *reportlength*	0~127	Value	Minute		integer	If R_V<=59, report_period = R_V If R_V>59, report_period = (R_V-59)*60 The codec will calculate the report period value and return it in the "*reportlength*" attribute
7	Report ID / *reportid*	0~9	Value		[0, 9]	integer	Used to identify the message (increased with each transmission)
8	Vibration level (vl_1) / *vibrationlevel*	0~127	Value				
9	Vibration level (vl_2) / *vibrationlevel*	0~127	Value	g	[0,127]	float	Max amplitude value (on 3 bytes) vl=(vl_1*128+vl_2+vl_3/100)/10/121.45 The codec will calculate the maximum vibration level value and return it in the "*vibrationlevel*" attribute
10	Vibration level (vl_3) / *vibrationlevel*	0~127	Value				
11	Peak frequency index / *peakfrequencyindex*	0~256	Value+1		[0,256]	integer float	Frequency index value with the highest vibration level recorded Freq_index=Value+1; The codec will calculate the Frequency index value and return it in the "*peakfrequencyindex*" attribute If *peakfrequencyindex* value is <128 then Peak frequency step =3,125Hz and the corresponding peak frequency value is Frequency_value=(Value+1)*FREQ_SAMPLING_ACC_LF/256 If *peakfrequencyindex* value is >= 128 then Peak frequency step =100Hz and the corresponding peak frequency value is Frequency_value=((Value & 0x7F)+1)*FREQ_SAMPLING_ACC_HF/256 The Frequency value is not calculated by the codec and must be calculated by the web application.
12	[10%-20%] anomaly level time / *badvibrationpercentage1020*	0~127	(Operating time - [0%-10%] anomaly level time)*Value/127	Minute	[0, report_period]	integer	Time, in minutes, spent in the [10%-20%] anomaly level range over the report period The codec will return in the attribute "*badvibrationpercentage1020*" the percentage of time spent in the [10;20%] vibration drift range over the last period
13	[20%-40%] anomaly level time / *badvibrationpercentage2040*	0~127	(Operating time - [0%-10%] anomaly level time)*Value/127	Minute	[0, report_period]	integer	Time, in minutes, spent in the [20%-40%] anomaly level range over the report period The codec will return in the attribute "*badvibrationpercentage2040*" the percentage of time spent in the [20;40%] vibration drift range over the last period
14	[40%-60%] anomaly level time / *badvibrationpercentage4060*	0~127	(Operating time - [0%-10%] anomaly level time)*Value/127	Minute	[0, report_period]	integer	Time, in minutes, spent in the [40%-60%] anomaly level range over the report period The codec will return in the attribute "*badvibrationpercentage4060*" the percentage of time spent in the [40;60%] vibration drift range

Byte	Definition / *codec attribute*	Value (dec)	Real_Value (dec)	Unit	Range	Type	Comments
							over the last period
15	[60%-80%] anomaly level time / *badvibrationpercentage6080*	0~127	(Operating time - [0%-10%] anomaly level time)*Value/127	Minute	[0, report_period]	integer	Time, in minutes, spent in the [60%-80%] anomaly level range over the report period. The codec will return in the attribute "*badvibrationpercentage6080*" the percentage of time spent in the [60;80%] vibration drift range over the last period
16	[80%-100%] anomaly level time / *badvibrationpercentage80100*	0~127	(Operating time - [0%-10%] anomaly level time)*Value/127	Minute	[0, report_period]	integer	Time, in minutes, spent in the [80%-100%] anomaly level range over the report period. The codec will return in the attribute "*badvibrationpercentage80100*" the percentage of time spent in the [80;100%] vibration drift range over the last period
17	Battery percentage / *batterypercentage*	0~127	Value*100/127	%	[0,100]	integer	Remaining battery level. The codec will calculate the battery level and return it in the "*batterypercentage*" attribute
18	24h 20% Anomaly level prediction / *anomalylevelto20last24h*	0~255	Value	hour	[0,255]	integer	Time, in hour, when anomaly level is expected to reach 20% (Prediction based on the data of last 24 hour) **255=infinite time**
19	24h 50% Anomaly level prediction / *anomalylevelto50last24h*	0~255	Value	hour	[0,255]	integer	Time, in hour, when anomaly level is expected to reach 50% (Prediction based on the data of last 24 hour) **255=infinite time**
20	24h 80% Anomaly level prediction / *anomalylevelto80last24h*	0~255	Value	hour	[0,255]	integer	Time, in hour, when anomaly level is expected to reach 80% (Prediction based on the data of last 24 hour) **255=infinite time**
21	30days 20% Anomaly level prediction / *anomalylevelto20last30d*	0~255	Value	day	[0,255]	integer	Time, in days, when anomaly level is expected to reach 20% (Prediction based on the data of last 30 days) **255=infinite time**
22	30days 50% Anomaly level prediction / *anomalylevelto50last30d*	0~255	Value	day	[0,255]	integer	Time, in days, when anomaly level is expected to reach 50% (Prediction based on the data of last 30 days) **255=infinite time**
23	30days 80% Anomaly level prediction / *anomalylevelto80last30d*	0~255	Value	day	[0,255]	integer	Time, in days, when anomaly level is expected to reach 80% (Prediction based on the data of last 30 days) **255=infinite time**
24	6months 20% Anomaly level prediction / *anomalylevelto20last6mo*	0~255	Value	month	[0,255]		Time, in months, when anomaly level is expected to reach 20% (Prediction based on the data of last 6 months) **255=infinite time**
25	6months 50% Anomaly level prediction / *anomalylevelto50last6mo*	0~255	Value	month	[0,255]		Time, in months, when anomaly level is expected to reach 50% (Prediction based on the data of last 6 months) **255=infinite time**
26	6months 80% Anomaly level prediction / *anomalylevelto80last6mo*	0~255	Value	month	[0,255]		Time, in months, when anomaly level is expected to reach 80% (Prediction based on the data of last 6 months) **255=infinite time**

See *§ 2.6 P* for details on FREQ_SAMPLING_ACC_LF and FREQ_SAMPLING_ACC_HF

3.3.2. Report message payload data extraction example

Report payload:0x72087f5a00353e090019260c552a0000007c77ffffffffffffffff

byte	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	-	-	-	-	-	-	-	26
	72	08	7f	5a	00	35	3e	09	00	19	26	0c	55	2a	00	00	00	7c	77	ff	ff	ff	ff	ff	ff	ff	ff

Byte	Definition	hex	dec	Value	Unit	Comments
0	Header	72	114	114 =ASCII "r" =>Report frame	-	Report header
1	Anomaly level (in %)	08	8	8*100/127=6.3	%	Calculated over « machine on » time
2	Operating time	7f	127	127*180/127=180	min	Report length=180 minutes Operating rate in percentage: [decimal Value]*100/127
3	[0%-10%] anomaly level time	5a	90	90*180/127=128	min	To get the value in percentage: [value in min]/[Report period]*100
4	Alarm Number	00	0	0	-	No alarms during this report period
5	Temperature	35	53	53-30=23	°C	Hardware offset
6	Report period (R_V)	3e	62	62>59 => Report period = (value – 59) * 60=(62-59)*60=3*60 =180	min	If value < 59 →= value If value > 59 →= (value – 59) * 60
7	Report ID	09	9	9	-	9th report (next report ID will reset to 0)
8	Maximum vibration amplitude (3 bytes) Vibration level 1 (vl_1)	00	0	$vl=(vl\_1*128+vl\_2+vl\_3/100)/10/121.45$ => $vl=(0*128+25+38/100)/10/121.45$ $vl=0.0209$	g	vl=0.0209g
9	Vibration level 2 (vl_2)	19	25			
10	Vibration level 3 (vl_3)	26	38			
11	Peak frequency index (frequency with the highest vibration level recorded)	0c	12	Freq_index=Value+1=13 Freq_value=(Value+1)*FREQ_SAMPLING_ACC_LF/256=13*800/256=40,625	- Hz	Freq_index=13 Freq_value=40,625Hz (reminder: FREQ_SAMPLING_ACC_LF=800)
12	[10%-20%] anomaly level time	55	85	(180–128)*85/127=35	min	Raw data of time in anomaly in the payload are given on the « bad vibration » period : operating time–[0-10%] time To have the value in percentage: [value in minutes]/[Report period]*100
13	[20%-40%] anomaly level time	2a	42	(180–128)*42/127=17	min	Raw data of time in anomaly in the payload are given on the « bad vibration » period : operating time–[20-40%] time To have the value in percentage: [value in minutes]/[Report period]*100
14	[40%-60%] anomaly level time	00	0	(180–128)*0/127=0	min	Raw data of time in anomaly in the payload are given on the « bad vibration » period : operating time–[40-60%] time To have the value in percentage: [value in minutes]/[Report period]*100
15	[60%-80%] anomaly level time	00	0	(180–128)*0/127=0	min	Raw data of time in anomaly in the payload are given on the « bad vibration » period : operating time–[60-80%] time To have the value in percentage: [value in minutes]/[Report period]*100
16	[80%-100%] anomaly level time	00	0	(180–128)*0/127=0	min	Raw data of time in anomaly in the payload are given on the « bad vibration » period : operating time–[80-100%] time To have the value in percentage: [value in minutes]/[Report period]*100
17	Battery percentage	7c	124	124 x 100 / 127 = 97,6	%	Estimated, based on current consumption and time spent in each mode (data acquisition, IA processing, Lora transmission, sleep mode)
18-26	Anomaly forecasts 24h:20%-50%-80% 30d:20%-50%-80% 6m:20%-50%-80%	77 ff ff ff ff ff ff ff ff	119 255 255 255 255 255 255 255255	119/ / / / / / / / /	hours days months	Forecasts are calculated with a linear regression, using data of the previous 24h, respectively 30 days, and 6 months. If value = 255, it means infinite time, we suggest not to display any value

3.4. ALARM MESSAGE

3.4.1. Payload structure

Evolutions compared to previous version of the device are in red in the following table

Byte	Definition / *codec attribute*	Value (dec)	Real_Value (dec)	Unit	Range	Type	Description
0	Header / *alarm*	97		const		N/A	hex=0x61 => **a**larm header
1	Anomaly level / *anomalylevel*	0~127	Value*100/127	%	[0,100]	float	Anomaly level recorded for the alarm The codec will calculate the battery level value and return it in the "*anomalylevel*" attribute
2	Temperature / *temperature*	0~127	Value-30	°C	[-30,97]	integer	Temperature measured for the sample, which triggered the alarm event (default anomaly level for the alarm trigger is 25%, can be changed through a Downlink command, see corresponding chapter) The codec will calculate the temperature value and return it in the "*temperature*" attribute
3	NA	NA	NA		NA		Reserved for future use
4	Vibration level (vl_1) / *vibrationlevel*	0~127	Value				Vibration level measured for the sample, which triggered the alarm event vl=(vl_1*128+vl_2+vl_3/100)/10/121.45
5	Vibration level (vl_2) / *vibrationlevel*	0~127	Value	g	[0,127]	float	The codec will calculate the maximum vibration level value and return it in the "*vibrationlevel*" attribute
6	Vibration level (vl_3) / *vibrationlevel*	0~127	Value				
7	Peak frequency index / *peakfrequencyindex*	0~256	Value+1		[0,256]	integer float	Frequency index value with the highest vibration level recorded Freq_index=Value+1; The codec will calculate the Frequency index value and return it in the "*peakfrequencyindex*" attribute If *peakfrequencyindex* value is <128 then Peak frequency step =3,125Hz and the corresponding peak frequency value is Frequency_value=(Value+1)*FREQ_SAMPLING_ACC_LF/256 If *peakfrequencyindex* value is >= 128 then Peak frequency step =100Hz and the corresponding peak frequency value is Frequency_value=((Value & 0x7F)+1)*FREQ_SAMPLING_ACC_HF/256 The Frequency value is not calculated by the codec and must be calculated by the web application
8~39	FFT signal (needed to be calculated with vibration level) / *fft*	0~127		g; Hz		float float	FFT signal measured for the sample, which triggered the alarm event Value_g=Value*vl/127; (see bytes 2-3-4 for vl value calculation) The codec will calculate the g value and return it in the "*fft*" attribute Frequency_hz=(i+1)*FREQ_SAMPLING_ACC_HF/256 (i is the index of FFT array, begins from 0, ends by 31)

3.5.   STATE MESSAGE

3.5.1. payload structure

(STATE message is the first applicative payload sent by the device after power-on)

Evolutions compared to previous version of the device are in red in the following table

Byte	Definition / *codec attribute*	Value (dec)	Real_Value (dec)	Unit	Range	Type	Comments
0	Header / *startstop*	83				N/A	hex=0x53 => **S**tate header
1	sensor & machine states / *state*	100~101; 104~105;110;125~126	(Value)			N/A	100: Sensor start; 101: Sensor stop; 104: Keep alive sent during the vibration testing cycle, there is not enough vibration to start learning 105: Vibration testing cycle timeout, device goes to poweroff 106: Learning mode keep alive message, sent when the machine goes off for a long time during a learning session 110: Machine stop with flash erase 125: Machine stop; 126: Machine start
2	Battery percentage / *batterypercentage*	0~127	Value*100/127	%	[0,100]	integer	Remaining battery level The codec will calculate the battery level and return it in the "*batterypercentage*" attribute

IV. Downlink (LoRa to device)

Note : Downlink commands have to be sent one by one.

4.1. Renew learning mode or add learning

Definition	Byte to send (hex)	Downlink Port
Restart learning from 0	0x50	1
Additional Learning	0x51	1

<u>Restart learning</u> will erase the previous vibration points map and learn up to 20 new vibration signatures
<u>Additional Learning</u> will learn new vibration signatures (adding the new vibration signatures to the one previously recorded, up to 20 in total)

4.2. Change sampling period

Evolutions compared to previous version of the device are in red in the following table

Definition	Learning period	Monitoring period	Downlink value (hex)	Downlink Port
Very Fast Mode	10 sec	20 sec	0x52	1
Fast Mode	20 sec	2 min	0X53	1
Legacy Mode	60sec	5 min	0x60	1
Default Mode	60 sec	**10** min	**0x54**	**1**
Slow Mode	2 min	10 min	0x55	1

4.3. Enable/disable machine start/stop STATE MESSAGE

Definition	Downlink value (hex)	Downlink Port
Enable State Message	**0x56**	**1**
Disable State Message	0x57	1

The Downlink message "Enable State Message" activates the start/stop machine notification (default configuration)
The Downlink message "Disable State Message" deactivates the start/stop machine notification (used mostly to spare sensor energy in case of frequent state transitions)

Note:
3.5 years warranty is guaranteed for nominal operation which implies:
- o **10 min period measurement**
- o **8 report messages per day**
- o **Occasionnal On/Off message**

Note: Start/stop messages and battery life
We recommend to automatically disable start/stop messages if the total number of message received during the first month of operation is more than 60.

4.4. Change ALARM MESSAGE threshold

Definition	Downlink value (hex)	Downlink Port
Alarm Threshold when anomaly > 10%	0x58	1
Alarm Threshold when anomaly > 15%	0x59	1
Alarm Threshold when anomaly > 20%	0x5A	1
Alarm Threshold when anomaly > 25%	**0x5B**	**1**

4.5. Reset battery value – New

This Downlink command is a new command for BoB V2

Definition	Downlink value (hex)	Downlink Port
Reset battery value to 100%	**0x5D**	**1**

4.6. Enable/disable frame acknowledgement – New

In certain conditions where the device is at the limit of the network reach, missing frame might occur too often. In that case, it is possible to activate frame acknowledge by the network to force retransmission for frames not getting the acknowledgement by the Network Server. Retransmission will be done 8 times maximum.

By default, frame ACK is disabled.

Definition	Downlink value (hex)	Downlink Port
Enable frame ACK	0x5E	1
Disable frame ACK	**0x5F**	**1**

Enabling frame acknowledgement will have some effect on battery lifespan as messages will be re-sent without acknowledgement reception, and each message will expect an Rx message.

4.7.   Change Vibration threshold for On/Off detection – New

Sometimes the environment can be very noisy with a lot of parazitic vibrations, due to close proximity with other highly vibrating equipments. It could happen that BoB analyses these vibrations and consider them as legitimate as the level will be high enough to consider that the machine is On.

In that case, it is possible to adjust the vibration threshold to consider that the machine is On or Off.

For example, a machine with a vibration level at 0.3g when On could sense 0.05g due to parasitic vibration when the machine is Off. In that case it will not consider the equipment as off, and report false inforamtion on the vibration of the equipment.

In that case, it is possible to send a downlink to the device to adjust the threshold to 0.155g for example. To do so, you need to put the value in dg (multiply by 100 the expected threshold):

New vibration threshold = 0.155g => value to send = 0.155x100 = 15.5 (10^{-2}g)

You then need to transform this float value into hex value:

15.5 ⇔ 0x41780000

To prepare the frame to send by downlink, you then need to put the hex value in LSB first format:

0x41 78 00 00
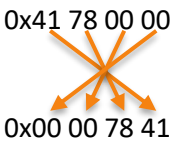
0x00 00 78 41

Then you just need to add the header of the frameto complete the payload to send:

5C00007841

| Definition	Downlink value (hex)	Downlink Port
Set minimum vibration threshold value	**0x5Ctttttttt**	**1**

With ttttttt = 10^{-2}g value converted in hex format with LSB first, e.g. 00007841 for 0.155g

Note: You can use an online decimal to hex converter to get the hex value from the float value (e.g. https://www.binaryconvert.com/)

V.   Charts examples

5.1.   Breakdown of the operating time of the machine

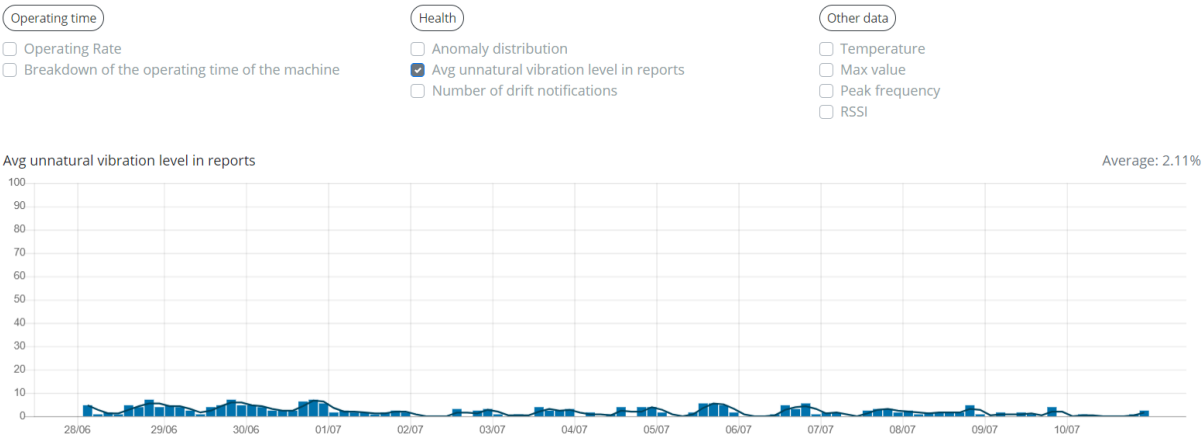Time of operation, expressed in minutes, over a 3 hours period of analysis.
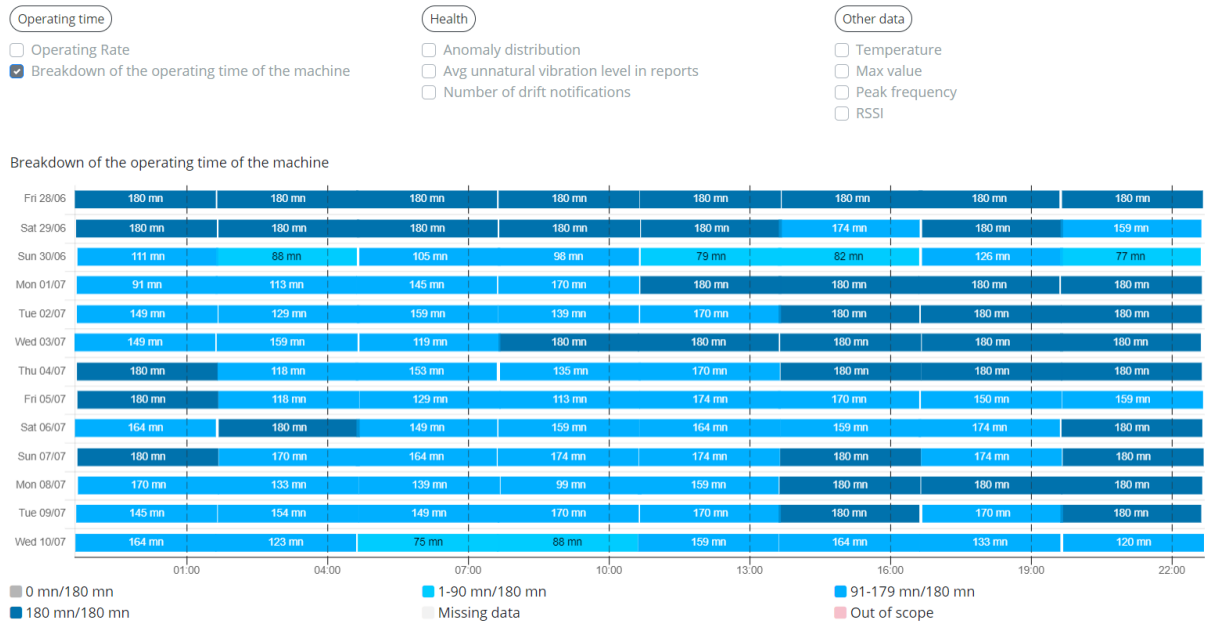
5.2.   Anomaly distribution

Displays the level of abnormal vibration, related to a percentage of time spent in each zone, from very good (green) to very bad (red). Each bar shows a 3hour period of time. Gray zone exhibits the time the machine is off
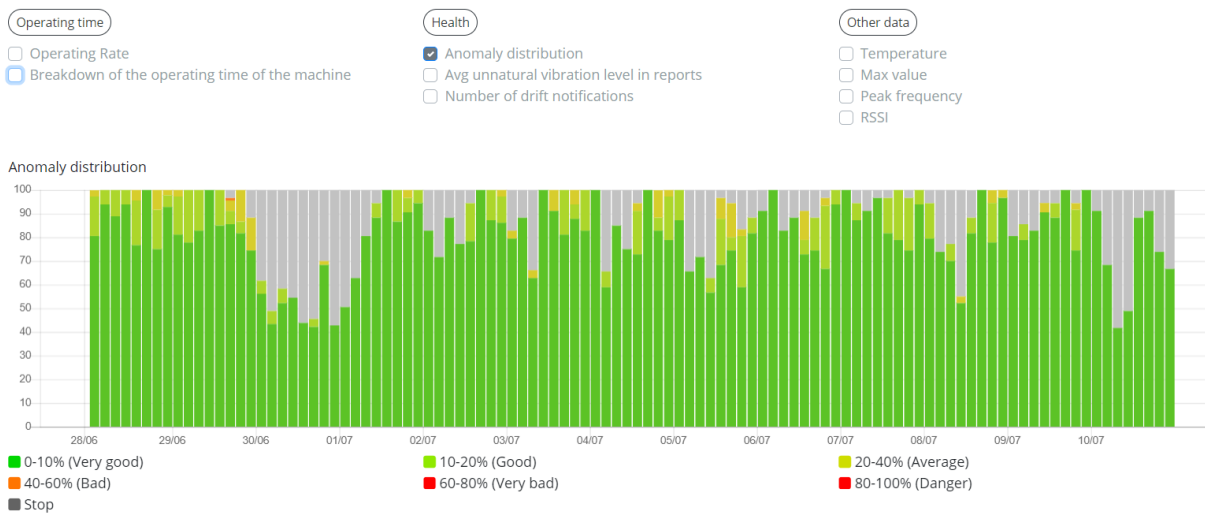
5.3. Average unnatural vibration level in reports

Vibration drift ratio average value, calculated over a 3 hours period, and compared to the reference vibration signature(s). Custom notifications can be set on this value
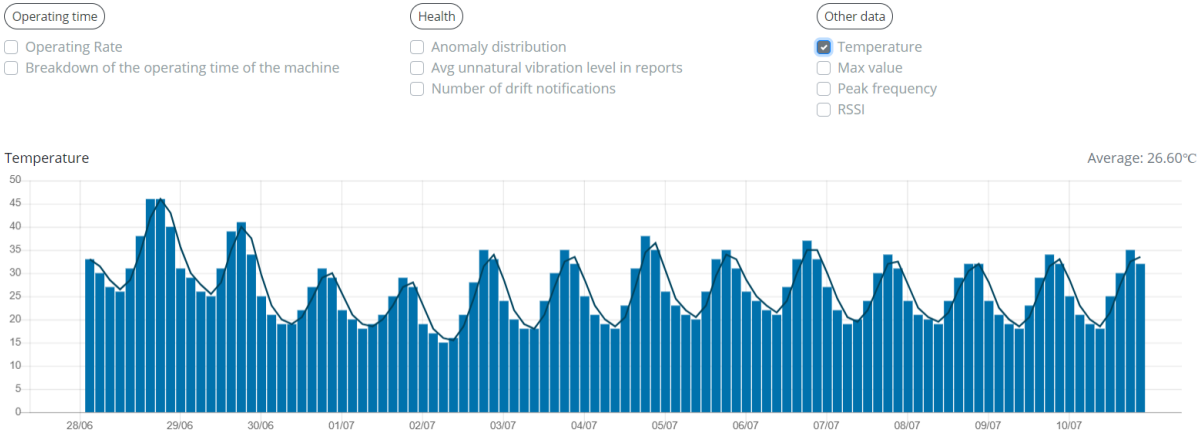
Operating time	Health	Other data
☐ Operating Rate	☐ Anomaly distribution	☐ Temperature
☐ Breakdown of the operating time of the machine	☑ Avg unnatural vibration level in reports	☐ Max value
	☐ Number of drift notifications	☐ Peak frequency
		☐ RSSI

Avg unnatural vibration level in reports   Average: 2.11%

5.4. Number of drift notifications

Number of alarms that BoB has sent, when anomaly level exceeds 25%

Operating time	Health	Other data
☐ Operating Rate	☐ Anomaly distribution	☐ Temperature
☐ Breakdown of the operating time of the machine	☐ Avg unnatural vibration level in reports	☐ Max value
	☑ Number of drift notifications	☐ Peak frequency
		☐ RSSI

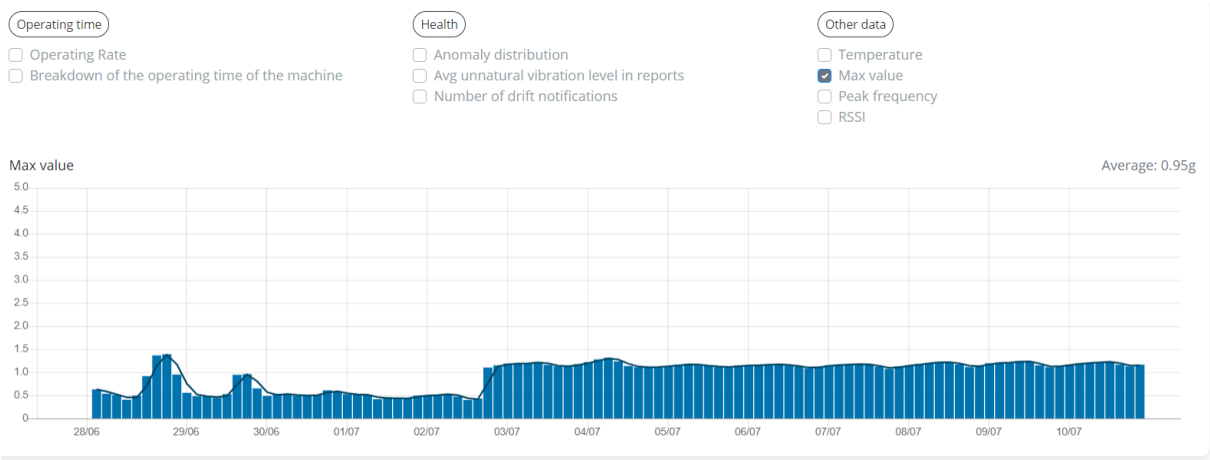Number of drift notifications   Total: 2
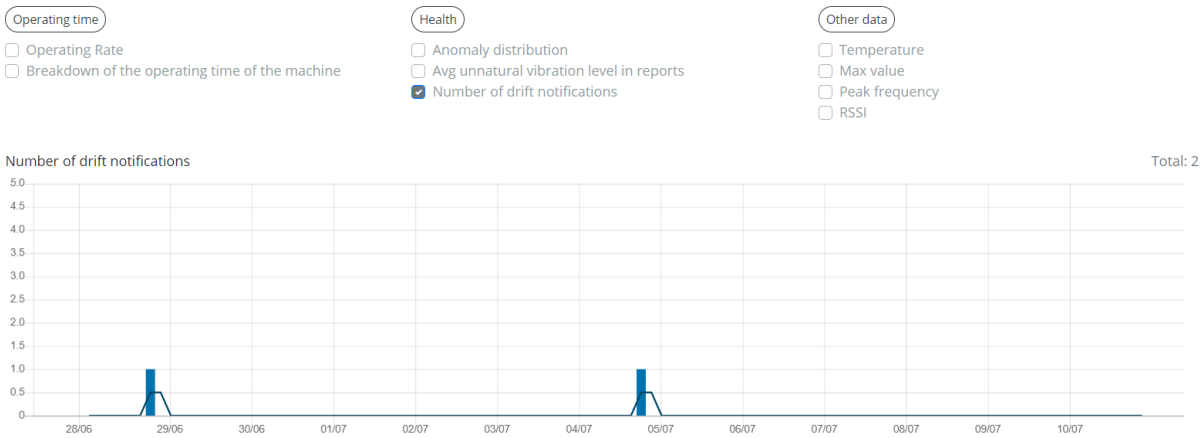
5.5. Temperature

Average temperature reported every 3h. Please note that this temperature is not the surface temperature of your machine, but an ambient average value measured inside the sensor casing.
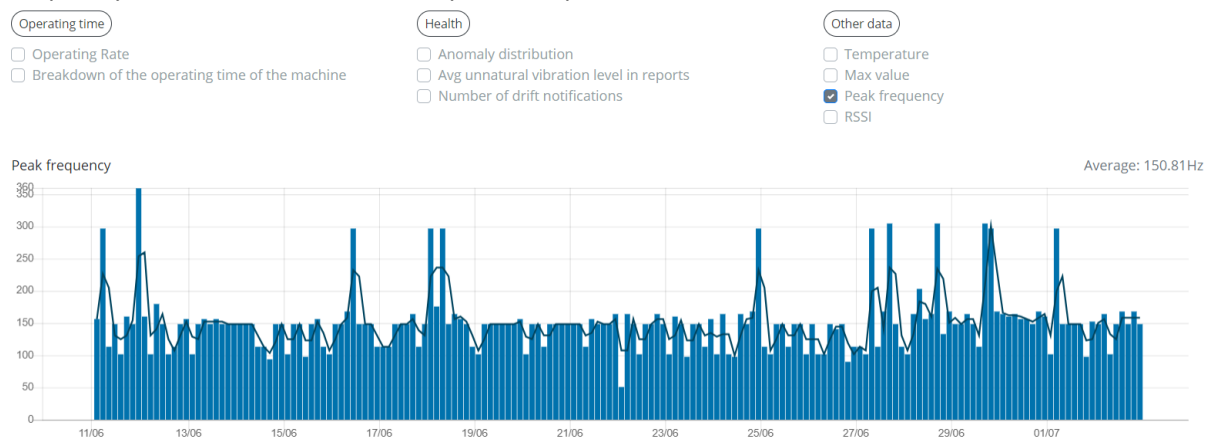
Operating time	Health	Other data
☐ Operating Rate	☐ Anomaly distribution	☑ Temperature
☐ Breakdown of the operating time of the machine	☐ Avg unnatural vibration level in reports	☐ Max value
	☐ Number of drift notifications	☐ Peak frequency
		☐ RSSI

Temperature   Average: 26.60℃

5.6. Maximum vibration value

Maximum vibration amplitude in [g].

5.7. Peak Frequency

Frequency related to the maximal amplitude reported
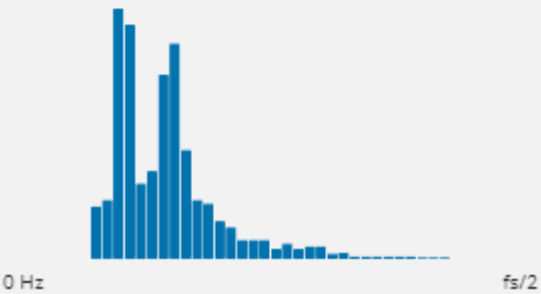
5.8. Report view

Anomaly prediction / Observed period	Last 24 hours	Last 30 days	Last 6 months
Anomaly 20 %	0 hours	infini	infini
Anomaly 50 %	194 hours	infini	infini
Anomaly 80 %	infini	infini	infini

5.9. Vibration drift Alarm view

VI.   Payload examples

A javascript codec (ES5 and ES6) is provided to decode the frames sent by the device. It is available at the following URL : https://github.com/Watteco/Codec-BoBAssistant-Javascript

6.1.   Raw payload

Type	Payload cleartext (hex)	frame number	Comment
UPLINK	6137320003105C0E201F45462A171F18483E454C285D7F37241610181C10180D0E0E070C110C0A0C	10	Anomaly
UPLINK	72097f5f00313e0700284c537f000000007cffffffffffffffffff	9	Report
UPLINK	537e7d	8	machine on
UPLINK	537d7d	7	machine off
UPLINK	6c64002d190133014c7f4731542f383531263326292c403046433d472c181e252e34232c38202531	6	Learning complete
UPLINK	6c5000333f013301407f3d25572f3228333b251c231b2e3831492d26241812181f1d182d2029383a	5	Learning 80%
UPLINK	6c3c00384b013301347f4f2a512830343a2221152d1c273242492d331e171618262413221b2d3841	4	Learning 60%
UPLINK	6c2800394e013301417f432b4f2f36232d23261c242731233a452d341714171a261f1c2324333738	3	Learning 40%
UPLINK	6c140031150134013c7f3c284b2a393f29321f1e223248294754492b191616202720212a2d28383b	2	Learning 20%
UPLINK	6c00001f3f013601407f5b4467393c303176301c332b61345b7e303e2318373f333f2231444a4245	1	Learning process start
UPLINK	53647f		Sensor start
JOIN			

6.2. Frame decode examples

6.2.1. LEARNING TYPE

Payload: [6c6401015c0a3b0104067f0b060f6706051f130f41170714070714280813250704030302020202]

```
{
  "type": "learning",
  "sensor": "KX",
  "msg": {
    "temperature": 29,
    "learningfromscratch": 1,
    "learningpercentage": 100,
    "vibrationlevel": 0.107,
    "peakfrequencyindex":11,
    "peakfrequency":34.38,

    "fft": [
      0.0034,
      0.0051,
      0.107,
      0.0093,
      0.0051,
      0.0126,
      0.0868,
      0.0051,
      0.0042,
      0.0261,
      0.016,
      0.0126,
      0.0548,
      0.0194,
      0.0059,
      0.0168,
      0.0059,
      0.0059,
      0.0168,
      0.0337,
      0.0067,
      0.016,
      0.0312,
      0.0059,
      0.0034,
      0.0025,
      0.0025,
      0.0017,
      0.0017,
      0.0017,
      0.0017,
      0.0017
    ]
  }
}
```

6.2.2. REPORT TYPE

Payload: [720D7F27013B0206001B011A7F000000007FFFFFFFFFFFFFFFFFFF]

```
{
  "type": "report",
  "sensor": "KX",
  "msg": {
    "batterypercentage": 100,
    "anomalylevel": 10.2,
    "anomalylevelto20last6mo": 255,
    "nbalarmreport": 1,
    "operatingtime": 2,
    "totalunknown6080": 0,
    "totalunknown4060": 0,
    "totalunknown2040": 0,
    "anomalylevelto80last30d": 255,
    "vibrationlevel": 0.0222,
    "totalunknown1020": 1,
    "anomalylevelto80last6mo": 255,
    "anomalylevelto50last24h": 255,
    "anomalylevelto20last24h": 255,
    "anomalylevelto50last30d": 255,
    "temperature": 29,
    "reportlength": 2,
    "anomalylevelto20last30d": 255,
    "peakfrequencyindex": 27,
    "totalunknown80100": 0,
    "totaloperatingtimeknown": 1,
    "anomalylevelto50last6mo": 255,
    "anomalylevelto80last24h": 255
  }
}
```

6.2.3. ALARM TYPE

Payload: [611C3B010044351C7F121D1D101D2F302B291E15110C0909080807070605040303020201020102]
{
  "type": "alarm",
  "sensor": "KX",
  "msg": {
    "temperature": 29,
    "vibrationlevel": 0.0564,
    "anomalylevel": 22,
    "fft": [
      0.0564,
      0.008,
      0.0129,
      0.0129,
      0.0071,
      0.0129,
      0.0209,
      0.0213,
      0.0191,
      0.0182,
      0.0133,
      0.0093,
      0.0076,
      0.0053,
      0.004,
      0.004,
      0.0036,
      0.0036,
      0.0031,
      0.0031,
      0.0027,
      0.0022,
      0.0018,
      0.0013,
      0.0013,
      0.0013,
      0.0009,
      0.0009,
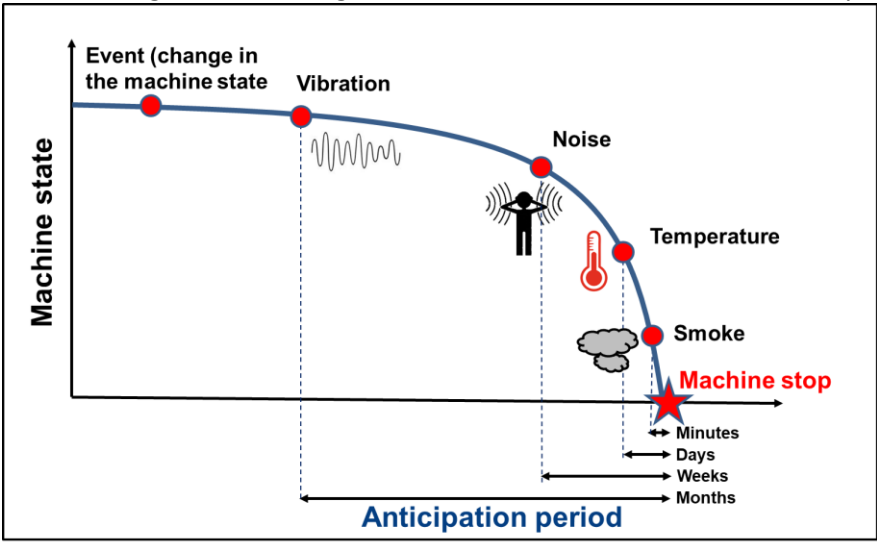   0.0004,
      0.0009,
      0.0004,
      0.0009
    ]
  }
}

6.2.4. STATE TYPE

Payload: [53647F]
```
{
  "type": "state",
  "sensor": "KX",
  "msg": {
    "state": 0,
    "batterypercentage": 100
  }
}
```

VII.   Frequently Asked questions

7.1.   Why monitor vibrations and their drift?

When the state of a rotating machine changes, vibration drift is the first measurable symptom:

However, a distinction must be made between breakdowns due to wear or tear (slow drift) and breakage (fast drift). The increase in the level of the anomaly can therefore sometimes occur only a few days before the failure. The maintenance team will always be the most able to analyse and intervene on the equipment when BoB ASSISTANT reports an anomaly.

7.2.   What are the main causes of vibration anomaly?

Possible cause	Corresponding frequency
Off balance	Rotation frequency
Misalignment	2 x rotation frequency
Bearing fault	3 to 10 x rotation frequency [2kHz - 60KHz]
Instability	Natural frequency of the equipment
Belt fault	Rotation frequency + harmonics
Fan fault	Number of blades x natural frequency
Electrical fault	Line frequency (50Hz) + harmonics
Gear	Natural frequency x number of gears
Natural frequency resonance	Natural frequency

7.3.   Which type of equipment is well suited for BoB ASSISTANT?

BoB ASSISTANT measures the vibrations of a machine and analyses its evolution over time. Vibration signature deviations are detected in real time and an alert is sent if the deviation exceeds a 25% threshold. In addition, the projections predict the level of anomaly in the coming weeks/months.

Also, BoB ASSISTANT will work very well on equipment with one or several stationary vibration regimes

| Air Compressor | Motor | Air conditionning group | Oven |

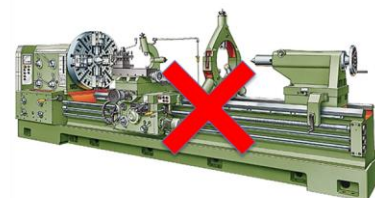| Pump | Suction turbine | Central air treatment | Stove |

On the other hand, equipment in motion or exhibiting random or time-varying vibration regimes will not be eligible for the BoB ASSISTANT offer:

| Rolling/Moving stocks | Automated arms | Machine-tool / short cycles |

7.4.   What is the temperature limit?

The surface temperature of your equipment must not exceed 55°C.

7.5.   When should BoB ASSISTANT be installed on the equipment?

BoB ASSISTANT performs a vibration signature training during the first 7 days after it is turned ON. During this period, it is crucial that the vibration signature is as close as possible to normal/representative machine operation. It is therefore strongly recommended to start BoB ASSISTANT on new equipment or most commonly, shortly after a maintenance operation.

7.6.   Can we start BoB ASSISTANT on a machine that is not running?

If your machine is stopped during installation, you can still position BoB ASSISTANT and start it. The learning procedure will start when the equipment is back on. You must still make sure that the vibration is sufficient at this position. In case of doubt, it is preferable to install BoB ASSISTANT on a machine in operation.

7.7. Can BoB ASSISTANT or the machine be moved without disrupting its operation?

No. The learning of the vibration signature is closely linked to the positioning of the sensor on the machine, its orientation and its environment. Changing these conditions requires a relearning which can be done by turning the product OFF with flash erase and then back ON.

The addition of a vibrating machine near the monitored equipment can also disrupt the operation of BoB ASSISTANT and cause additional alerts. In this case it is recommended to adjust the threshold as detailed in *§ 0*

Change Vibration threshold for On/Off detection – New

## 7.8. What is the autonomy of BoB ASSISTANT V2 sensors?

In its standard use, BoB ASSISTANT's autonomy is a minimum of 3.5 years.

The autonomy of Bob is estimated by counting the number of messages sent, in addition to embedded calculus

If your machine has many stop and start cycles during the course of a day, the start/stop messages will be numerous and will have a strong impact on BoB ASSISTANT's autonomy. Beyond 2 start/stop per day, it is recommended to disable these messages. The time and operating rate will always be available in the reports sent every 3 hours.

7.9. How to evaluate LoRa coverage? What is the operating limit?

Depending on the environment of the sensor, it is sometimes hard to define if a Public Network will cover BoB location. The best way to know the strength of the real signal is to measure it with a dedicated sensor (you can use our Netw'O solution for example)

-120dBm	-100dBm	-80dBm	0dBm
Out of range	Average	Good	Very good
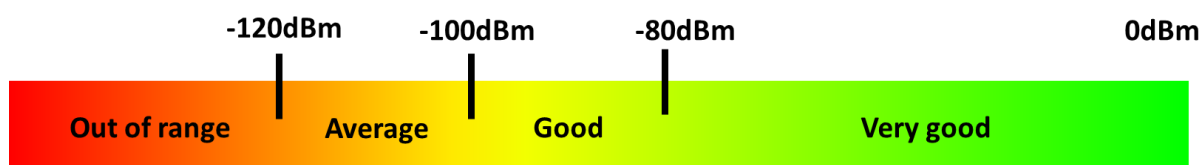
RSSI : Strength of the radio signal sent by Bob at the Gateway level (risk of message loss/missing data)

7.10. First learning and complete learning, what is the difference?

As BoB ASSISTANT starts, it initiates a first learning phase. This phase can be more or less long depending on the type of equipment, the complexity of its vibration signature and the number of operating speeds. It can last between 1 hour for the simplest systems and a few days for complex equipment.

You can track the progress of the learning on your dashboard, with a report sent every 20%.

After the first learning session, BoB ASSISTANT starts sending machine status data. A report is sent every 3 hours. However, BoB ASSISTANT stays tuned for 7 days and continues to learn. It analyses the new perceived vibrations, compares them to those already learned, and records them if they are relevant. It is therefore normal to see the level of abnormality gradually reduce during the first week. There will be no alerts sent during this 7 days.

After 7 days, BoB ASSISTANT has completed its training and is watching over your machine.

7.11. Bob started his learning but does not complete it. Why?

- **Discontinuous operation**: The machine operates very discontinuously and the learning process is paused when it is stopped. It resumes when the machine is restarted, but the complete learning session will take longer. If the 20% progress is not reached after 24 hours, see the following explanation.
- **Unsufficient vibration**: BoB ASSISTANT does not pick up enough vibration. Typically, **if the vibration intensity is below 0.02g, BoB ASSISTANT will not be able to learn correctly**. The vibration amplitude information is given by the learning report (see §*3.2 LEARNING MESSAGE*) . In this case, we recommend moving the sensor closer to the machine's vibration source (motor, compressor, etc.)

7.12. Why one BoB ASSISTANT is taking more time to complete its learning than another one?

The complete learning mode lasts 7 days. The first learning session lasts between 1 hour and a few days depending on the complexity of the vibration signature (number of vibration sources…).

An intermittent device, for example, will take longer to analyze because the learning is stopped if the machine is switched off. It will resume when the machine restarts.

7.13. Why is BoB ASSISTANT learning several time in the first week of operation?

After his first learning session, BoB ASSISTANT improves and continues to analyze the vibratory phenomena of the machine for 7 days. You are informed of a new learning phase by a Learning message. It is also normal for BoB ASSISTANT to refine its reports on the behaviour of your machine during the first week.

BoB ASSISTANT can learn up to 20 different vibration regimes.

At the end of the 7 days, the analysis is stabilized and BoB ASSISTANT only alerts you when actual drifts are observed.

7.14. How to make an additional learning or start BoB ASSISTANT over?

To reset BoB ASSISTANT, simply press and hold (20 seconds) the device button. By restarting BoB ASSISTANT after a flash erase process, it then restarts its learning mode as it did when it was first powered up.

To trigger a complete relearning, or a complementary learning, you can also use the Downlink commands described in § *4.1 Renew learning mode or add learning*

7.15. Some data are missing?

The main reason for data loss is a bad/low LoRa network coverage. You can check the signal strength using the RSSI indicator provided by your LoRa Network Server:
- from 0 to -90dBm: good coverage, no risk of data loss
- from -90dB to -110dBm: medium coverage, low risk of data loss
- -110dBm and lower: low coverage, proven risk of data loss
The metallic environment can also cause message loss (Faraday cage effect)

It is now possible to activate messages Acknowledgement (ACK), by sending the corresponding Downlink command, see *§4.6 Enable/disable frame acknowledgement – New*

7.16. Missing data and operating time

If LoRa network coverage is low, Report messages may exceptionally not be received and will not appear in your stream. Frames not received should be excluded from the operating rate: the corresponding 3 hours

should not be taken into account.

On the other hand, if you notice many missing Report messages, we recommend adding a LoRa gateway to improve LoRa network performance.

7.17. BoB ASSISTANT did not detect any anomalies, however, a failure occurred. What to do about it?

Check that BoB ASSISTANT has been positioned as close as possible to the vibration source. If your machine has several sources of vibration, it may be interesting to place several BoB ASSISTANTs on the equipment, especially on complex and bulky machines.

A wear or breakdown are almost always preceded or accompanied by a change in the vibration signature.

7.18. What is the difference between alarm and notification?

An alarm is sent by BoB ASSISTANT when it detects an anomaly greater than 25%. This generic value was determined after hundreds of thousands of hours of experimentation with the solution and corresponds to the most common case: when the anomaly level reaches 25%, you should check your equipment.

However, each piece of equipment has its own vibration regime and adding notifications at the application level based on report data allow you to customize the alert thresholds according to your expectations and the criticality of your requirements. For more information on custom notifications, see the following paragraph.

7.19. How to configure a notification trigger threshold?

At the end of the learning mode the average abnormal vibration level is generally low (<10%). It is advisable to wait 3 weeks to observe this average level, and to establish a notification threshold accordingly.

It is therefore recommended that the application receiveing BoB Assistant data fo vizualisation on a dashboard also manages a notification system based on the average vibration drift level in reports. Example :
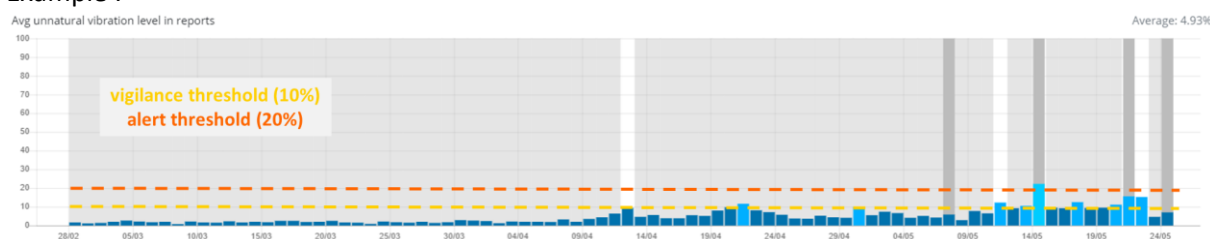
In this case, the average abnormal vibration level is 5%. The variations observed may correspond to the different phases of the machine (start-up, variations related to climatic conditions). A relevant alert threshold for notifications on abnormal vibration level is 10%. In case of an alert, this does not mean that your machine is in immediate danger but that vigilance is required.

You can also set up several notifications:
- 10% vigilance threshold
- 20% alert threshold (recommended physical intervention)

As a general rule, if a large number of notifications are received shortly after installation, the trigger threshold at the application level is probably too low and should be raised.

7.20. Why does the learning progress report indicate a value outside of expected values (20%, 40%...)?

If the machine is stopped during the learning process, BoB ASSISTANT detects it and pauses the learning. It will resume when the machine restarts.

However, if the machine stop exceeds a certain time, an activity report is sent (every 3 hours), indicating the progress, which can be blocked between 2 standard values.

7.21. Is it possible to check the activity and proper functioning of BoB ASSISTANT on request?

No. In its nominal operation, BoB ASSISTANT sends a report every 3 hours, and real-time alerts in case of unexpected events (vibration alarm, machine off...)

7.22. What is the range of BoB ASSISTANT (communication distance) in an industrial environment?

The LoRa modulation is dedicated to the transmission of short messages, at low transmission frequencies and over long distances. In free space (no obstacles) this range can reach several kilometers (up to 14km).
On the other hand, in an industrial environment, various metal equipment and structures are obstacles that create electromagnetic interference and reflections that can reduce BoB ASSISTANT's radio performance and range to a few hundred meters.
When a gateway is installed, the range in an industrial environment can go down between 50m to 500m

7.23. Are the transmitted data secure?

The data is encrypted using 2 layers of AES-128 encryption. This encryption is natively supported by the LoRaWAN protocol, as the payload is encrypted using a first key (AppSKey = Application Session Key) and the LoRaWAN header plus the encrypted payload are encrypted using a second key (NwkSKey = Network Session Key).
The session keys are derived from a symetric private key during the join session.

7.24. I started BoB ASSISTANT, but no message arrives on the application

Check that the network coverage is sufficient, and refer to the user manual to learn more about the LED sequences displayed by the sensor during startup.
Contact your integrator, platform provider to make sure that everything is ok on the Network Server and/or application platform declaration.

7.25. How do I position BoB ASSISTANT on my machine?

It is recommended to position BoB ASSISTANT on a flat and clean surface, as close as possible to the vibration source:
- On "simple" equipment (motor, pump, compressor): place BoB ASSISTANT directly on the equipment.
- On "complex" equipment: place BoB ASSISTANT on the chassis.

You can put your hand on the surface to feel the vibration. **FIRST MAKE SURE THAT THE SURFACE TEMPERATURE OF THE EQUIPMENT DOES NOT PRESENT A DANGER**

VIII.   Document history

V1.0 - 2023/04/04: First edition of BoB Assistant V2 Reference manual
V1.1 – 2023/05/09:
        Update 3D views
        Add ESD warning for battery replacement
        Typo correction for vibration threshold downlink (header is 5C not 5D)

--- end of document ---